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MAN:

HIS

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POPULARLY EXPLAINED AND DEMONSTRATED.

BY R. KNOX, M.D., F.R.S.E.,

LECTURER ON ANATOMY;

CORRESPONDING MEMBER OF THE IMPERIAL ACADEMY OF MEDICINE, OF FRANCE,

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ADVERTISEMENT.

Zoology, whether viewed as a department of human knowledge, or simply as a branch of general education, has for its basis Animal Structure and experimental Physiology. To omit these in a general scheme of education, or to overlook their importance in the study of those sciences which rest mainly on Zoology, such as Geology, Paleontology, and the Philosophy of the living and extinct animal world, is certain to reduce our knowledge of the animal kingdom to a mere terminology, alike tedious in its acquisition and unprofitable when acquired.

Of the various forms of life which decorate the globe we inhabit, that which the Creator has bestowed on Man himself is by far the most interesting, the most important. From it, as the most perfect, the most highly developed, the principles regulating the formation of nearly every other form of life may be deduced. Of this great fact—

namely, "the unity of the organization of all that lives"—the immortal Newton was well aware;* since his era, the principle he was the first to announce has been made the basis of extended inquiries; and thus, instinctively, as it were, most of those who have risen to great eminence in every walk in life, have endeavoured to acquire some knowledge of human anatomy, seemingly aware of the importance of such knowledge in enabling them not only to comprehend the great principles of all organizations, but correctly to appreciate the actual state of human knowledge. The author of this Work has selected the Human Structure for his descriptions and illustrations, as the best suited for his purpose, this, in truth, being the describing in simple language the leading facts of Animal Structure and the results of Experimental Physiology. On these facts and principles the student of Zoology may found whatever system of Philosophy he thinks fit. Systems change, and every era is characterized by a form of Philosophy adapted to the then existing condition of the human mind; but the facts of Anatomy, and the deductions of experimental Physiology, when rigorous, remain for ever true. Hence the unquestionable importance of that elementary instruction which

* Optics.

it is the object of this Work to impart. Without a knowledge of these facts and deductions, the general student can make no sound progress in Zoology; the professional student becomes an unsafe practitioner; the Paleontologist, a mere dreamer. Modern education aims at something more, it is true, than the mere facts of science; it aims at "a new interpretation of Nature." None can be more sensible of this important truth in the history of modern education, than the author of this Work. Long retarded by adverse circumstances, the human mind, as if anxious to make up for lost time, displays everywhere an extreme anxiety to comprehend the principles of the Philosophy of the organization of animal bodies; in this haste, there is danger—the danger of overlooking facts, and the deductions from facts, valuable only as based on them; the danger of forgetting that the Philosophy, which rests not on facts, is a vain structure, liable to be overthrown by a single experiment. Pallisset, the potter, demolished by a single remark the dreamy fancies which for centuries before his day had passed for philosophic theories. A fragment of bone, rightly interpreted, enabled the immortal Cuvier to demonstrate to mankind the truth and the consequences of Pallisset's wonderful discovery. If the student hopes, then, to interpret Nature aright, his education must be

based on the facts and principles contained in this little volume; their right comprehension will enable him, in the first place, to understand the true nature of those living forms which adorn the earth, which include his own structure and physiological history, and which, consequently, represent the grandest and most wonderful of all Nature's great designs; secondly, to comprehend the various "interpretations of Nature" which the illustrious dead have offered to the thoughtful of mankind; lastly, should Genius lend her aid to interpret the Book of Nature for himself.

The Author is anxious that the object of this Work be not misunderstood: it is simply an elementary and educational Work, containing such an outline of Human Structure and Human Physiology as may prove a safe basis whereon to build the edifice of special or philosophic inquiry and research.

LONDON,
OCTOBER, 1857.

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ATLAS.

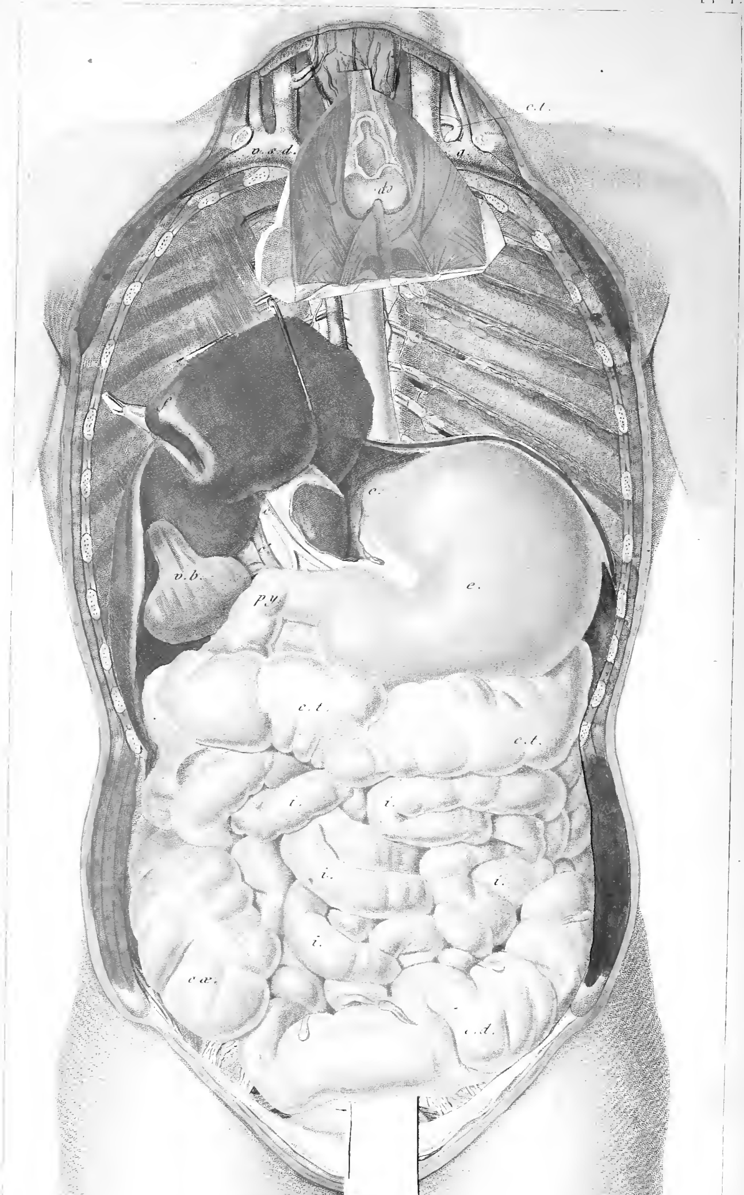
The Atlas accompanying this work is, to a certain extent, the invention of A. Comte, a distinguished French naturalist. The plates are mostly engraved on both sides, and are so arranged as to admit of being raised up and replaced, thus imitating those dissections, so difficult to make, and often so imperfectly understood when made. They are, therefore, topographical as well as descriptive, and even systematic in this respect, that they place before the student the assemblages of organs in a physiological order. Thus Plate 1, enables the reader to trace the progress of the food from the mouth to its passage into the torrent of the circulation of the blood, under the form of chyle; and so on with many others. I have thought it might be advantageous to describe these Plates at much greater length than has been done in the original Atlas, thus enabling, I trust, the student to profit by them, and to consult them with advantage at an early period of his studies. I have endeavoured, in short, to make their perusal independent of the text, a method which has been proved to answer even in strictly professional works.

EXPLANATION OF THE ENGRAVINGS.

This Atlas contains eight plates or engravings representing, as in a medallion or coin, both sides, that is the direct and the reverse, thus giving to the engraving, in as far as the art can give, the effect of a material representation. But it also contains other engravings, in which, in addition, certain figures have been cut into, or dissected, and superimposed, in order to preserve to the eye different layers and different surfaces of the same organs. The representations of these figures are so combined, that the two aspects, the *direct* and the *reverse* shew different planes, and thus bring out the relations of all the parts of the organ which serve to perform one function, and next the various layers admit of separation and reunion, so as to correspond to the descriptions in the text.

These layers or laminæ, moveable and articulated upon the principal figure, may be raised, in fact, like the leaves of a book, and the reader may, with their assistance, study the apparatus or assemblage of organs contributing to a function, dissected layer by layer, from the exterior of an organ, even into the folds of its texture.

In studying these engravings, any one in the slightest degree prepared for such pursuits may understand without an effort how the nutrition is effected, how the movements are accomplished, how the impressions on the senses are produced, &c.; in a word, the engravings become by the ingenuity of their construction, at once physiological and anatomical, and even descriptive or topographical, inas-



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much as the relations of the organs to each other are carefully preserved. Thus the great, and hitherto insurmountable difficulty of comprehending by the engraver's art alone, the topography of the complex structure of man, has by the ingenuity of the artist, and a combination of methods, been overcome, and nothing is left to the imagination of the student, which in such a case, unaided by such means, was sure to lead to error. The method is at once synthetical and analytical, physiological and anatomical, and can never mislead.

EXPLANATION OF PLATE I.

The object of this Plate is to display the interior arrangement of the cavities of the chest or thorax, and of the abdomen or belly; and in addition, the arrangement of the digestive organs contained within the cavity of the abdomen engraved on both sides, removeable at will, and easily replaced. By raising up the superimposed segment, the entire range of the posterior walls of the chest, abdomen, and partly of the pelvis, may be seen at once; in other words, the surfaces on which posteriorly the organs of respiration and of digestion rest. I shall first speak of what may be seen on this posterior wall, and next of the organs placed over it in front.

The reader will bear in remembrance that the object of the engraving is to display the digestive organs *in situ*,

that is in their natural situation as regards the plane or planes on which they rest, from the mouth to near the termination of the intestinal tube; and that the organs of respiration and the heart have been removed, and thus the interior of the chest is represented as empty. Without this arrangement, the œsophagus or gullet, and its course through the cavity of the chest could not have been shewn, for this tube lies at the back of the interior of the chest, in front of the spinal column, and close to its anterior aspect.

1. By raising up the head, the face is seen at once; the mouth is represented open, and the tongue is marked *l;* the lips, teeth, palate and uvula, together with the isthmus or passage from the mouth into the pharynx are well represented in the figure of the head as seen in front. By displacing the head and gullet forwards, may be observed the interior of the pharynx, the cavity having been laid open from behind. The pharynx is the cavity interposed between the mouth and the gullet; into this cavity the food and the air pass, the former on its way to the gullet, the latter *en route* for the lungs. Seven apertures enter or leave this cavity: two to the nostrils; one to the mouth; two to the ears; one to the air tube, and one to the gullet, it is to the last that we shall here attend. The letters *e, p,* are placed on the base of the tongue, below and behind which are situated the openings into the larynx, (top of the wind-pipe), and into the gullet.

We may next follow this tube, *œ,* on either side in its descent through the chest into the stomach; it represents of course the passage of the food, liquid and solid, from

the bag of the pharynx to the stomach. Its entrance into the stomach where it passes through the diaphragm, or midriff, is marked *c,* and on the stomach itself is placed the letter *e.* Now raise up the plate and observe the continuation of the stomach with the duodenum *d,* or commencement of the small intestine *i, i, i,* through which the food descends on its way to, *c, œ,* the cœcum, or beginning of the large intestines. This cœcum, with its appendix vermiformis, is but the first portion of the tube called large intestine; the portion following it is called the colon, divided into: 1, ascending; 2, transverse arch (marked *c, t*), descending colon (on the left side), sigmoid flexure of the colon *c, d,* and lastly the rectum which is not represented in this engraving, but which plunges into the cavity of the pelvis, and terminates the alimentary canal. These bowels or viscera may be studied on both sides of the engraving, and cannot be mistaken for any other.

Thus from the mouth to the termination of the alimentary canal there is, as it were, but one continuous tube, along which the solid and liquid aliment passes, during which lengthened course it is subjected to a variety of actions, mechanical, chemical and vital. The entire apparatus may be described as composed of:

1. Organs of	prehension.	The lips.
2. ,,	mastication. . . .	The teeth.
3. ,,	insalivation.	The salivary glands.
4. ,,	deglutition. . . .	Pharynx and gullet.
5. ,,	stomachal digestion. .	The stomach.

6. Organs of intestinal digestion and defœcation. . . . The tract of the intestines.

Connected with this lengthened tube are various appendages or accessory glandular organs, more or less important in the act of digestion, that is contributing to the conversion of the food into the liquid called chyle, that fluid out of which, no doubt, the blood is formed, and by which all the organs of the body are nourished. These appendages or accessory organs are: 1. The liver. 2. The pancreas. 3. The spleen. This latter organ is represented *in situ* on the left side of the large *cul de sac* of the stomach, and coloured of a purplish hue, but not lettered; the liver, (on the right side), is marked *f*, the gall bladder *v*, *b*, the hepatic duct *c'*, whilst *p*, 7, mark the anterior surface of that turn of the duodenum into which (but at the back) the common duct, from the liver and gall bladder enters the intestine. By reversing the engraving, the pancreas *p* is seen with its duct; this enters the duodenum at the point marked *d*.

These two large glands, the liver and the pancreas, play no doubt an important part in the conversion of the aliment into chyle; the first secretes the bile; the second the pancreatic juice. The spleen has no duct, and is not known to form any secretion; its functions therefore are, to a great extent, as yet unknown.

The food thus acted on assumes the form of a milky fluid called chyle, and under this form it is absorbed, or taken up by the vessels called *lacteals*. The discoverers

of these vessels named them *lacteals* from the milk-like fluid they contained. These lacteals proceed from the mucus or inner surface of the small intestine, and terminate at last in a reservoir called the receptaculum chyli, or receptacle of the chyle. From this receptacle starts the *thoracic duct,* one of the most important vessels of the body. By its means not only the greater part of the lymph absorbed throughout all the organs by the *absorbents,* but likewise the chyle itself is conveyed to the venous system, thus mingled with the general mass of the blood, conveyed to the heart and thence to the lungs, where undergoing the vivifying influence of the atmosphere, it becomes fitted for the nourishment of all the organs, and the support of life. To explain the course of the chyle, after it has reached the thoracic duct, is mainly the object of the second layer of Plate 1.

Raise up the portion of the engraving representing the great mass of the digestive organs, and underneath will be found a carefully engraved outline: 1st, of the structures on which these rest; 2d, of the thoracic duct, with numerous absorbing vessels proceeding to join it.

1. The posterior wall of the cavities of the thorax or chest, and of the abdomen or belly is now fully exposed, and may be thus described. In the middle or mesial plane is the vertebral column, extending quite into the pelvis. In the neck are seen the large vessels called the common carotid arteries, and internal jugular veins; in the chest, lower down, are the ribs and intercostal spaces and muscles.

In the abdomen and pelvis are represented the quadrati

lumborun muscles, the psoæ and iliac muscles, in the order I have enumerated them; outside these the divided edges of the large abdominal muscles which passing around enclose the digestive organs in front. These muscles have been removed.

2. In the mesial plane, and chiefly in front of the spine or vertebral column, are represented the thoracic duct *c t, c t,* commencing in the *reservoir of Pecquet,* or *receptaculum chyli, v, p;* and terminating in the left subclavian vein, *v, s, g,* near the angle of its junction with the internal jugular vein. Numerous lymphatic or absorbent vessels may be seen ascending from the pelvis and lower extremities to join the receptacle and thoracic duct. They bring the lymph from the lower extremities and from the pelvic organs, and pass through numerous absorbent glands in their course. The letters *v, s, d,* are placed on the right subclavian vein. The remarkable vein seen ascending through the chest to the right side of the thoracic duct is called the *vena azygos,* of the right side, and the vein seen crossing behind the thoracic duct, about the middle of the chest is the left vena azygos. The large venous trunks formed by the junction of the subclavian and internal jugular veins of either side are called venæ innominatæ; these unite to form the great vena cava superior which enters the right auricle of the heart.

Thus the product of digestion, the chyle, reaches the heart on its way to the lungs, mingled with the venous blood derived from the greater part of the supra-diaphragmatic or upper half of the body. The object, no doubt, of this arrangement or apparatus is to convey the chyle

Annedouche sc

and the venous blood ultimately towards the lungs, but why the chyle which is to restore the waste of the body, should previously to entering the venous system be mingled with the lymphatic fluid, is as yet unknown to physiologists.

EXPLANATION OF PLATE II.

This Plate shews the same parts as Plate 1, but in addition, by a most ingenious mechanism, the structure and physiological relations of several other organs are also displayed.

The head, which, in the engraving, is placed below its proper level, is to be gently drawn upwards so as to put it in its proper situation and relation to the trunk. By doing this, the stomach is raised and with it a large division of the small intestines. The structures thus displayed are as follows: they must be traced in layers, having regard both to their connections and superimposition, and to their physiological or functional nature.

1. The head and mouth are represented as in the preceding Plate; the tongue is marked *l*. On the posterior surface of the section may be seen, by lowering it, the pharynx laid open, communicating with the gullet and already described. (Pl. 1). The gullet, *c*, where it is just about to enter the stomach, *e*, has been, together with the stomach laid open anteriorly, (the latter, throughout its whole length,) and its inner or mucous membrane may

be seen arranged in folds running somewhat longitudinally from above downwards and from left to right. Towards the right side, where the letters *p, y,* are placed, is the pyloric opening by which the stomach communicates with the duodenum, the first division, *l,* of the smaller intestines. The orifice by which the gullet enters the stomach at *c,* is called its cardiac or œsophageal orifice, and by this orifice the food enters the stomach.

Now trace the duodenum downwards and note the rapid turn it makes. Raise up the stomach, marked *c,* posteriorly, and *p, y,* near its pyloric extremity, and observe how the duodenum terminates in the jejunum, or second great division of the small intestine. This intestine has also been laid open, and on the mesentery or fold of the peritoneum which supports it and attaches it to the spinal column, may be seen the letters *a, m, c,* directing attention to the mesenteric veins coloured blue, mesenteric arteries coloured red, and lacteals left uncoloured. These lacteals, as has been already said, (Pl. 1), arise on the mucous surface of the small intestine, and convey the chyle from the interior of the bowel to the left subclavian vein, where their terminating duct joins the venous system.

In addition to these letters, others are placed upon the opposing surfaces of this bowel; these are *v, c,* also marking the course of the lacteals from the intestine towards the receptacle of the chyle, or of Pecquet and the thoracic duct.

Before quitting the cavity of the abdomen, the student may as well note the position of the right and left kidneys, *r, r.* The left kidney has been laid open vertically

to display its structure, composed of a cortical part externally, and a medullary towards the centre; also the entrance of the renal artery, and the exit of the renal veins and of the ureter, which conveys the urine from the kidney to the bladder, the fundus or upper part of which may be seen in the lower part of the figure.

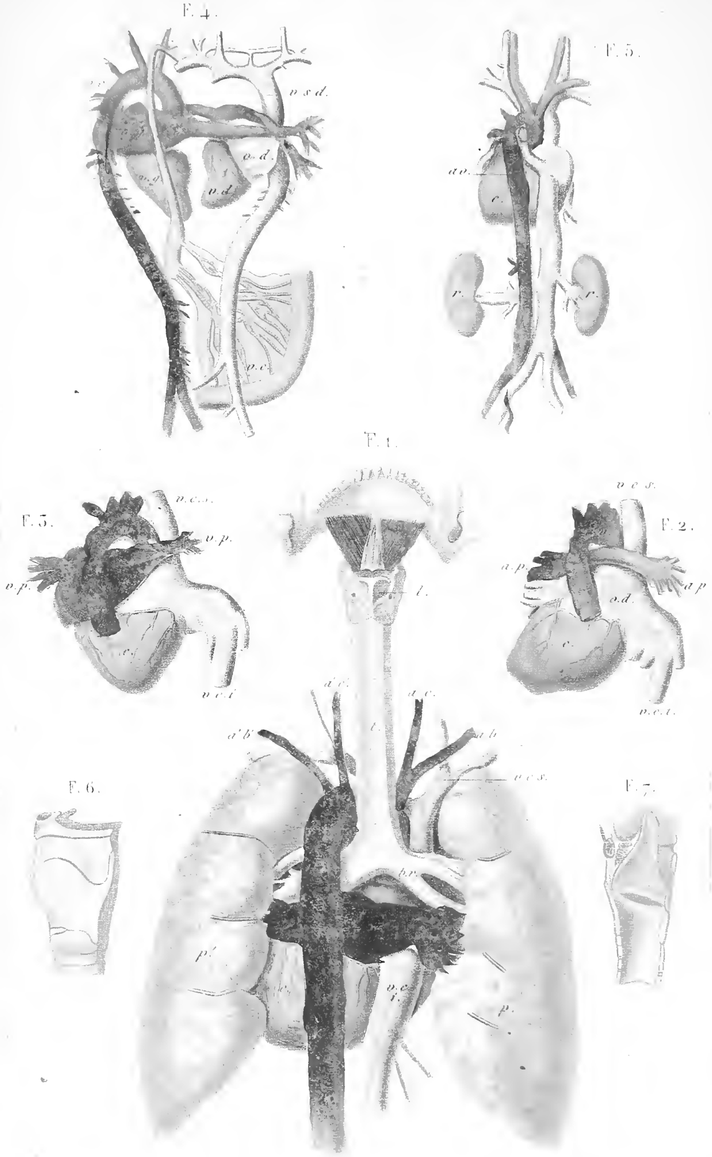
In addition, the engraving represents the vena cava inferior, *v, c,* conveying the blood from nearly all the parts below the diaphragm towards the heart. To the left of this is the aorta, *a, o,* the great artery of the body; the letters *l, r,* are placed on the arteries called common iliac, into which the aorta divides as it approaches the pelvis. Behind these may be seen, as in the preceding plate, the lacteals and lymphatics.

If we now direct our attention towards the chest, we perceive that the artist has represented the heart, and the roots of the lungs *in situ:* the heart has been left unopened, the roots of the lungs are represented as dissected.

o, d, mark the right auricle of the heart into which is poured all the venous blood coming from the body and heart itself, collected by the vena cava superior, *v, c, o,* the vena cava inferior *v, c, i,* and the coronary vein of which a branch may be seen near *c,* on the surface of the heart itself. From this right auricle, *o, d,* the blood is forced by the muscular contraction of its walls into the right ventricle, *v, d,* and its return prevented by a valve placed at the orifice of communication. Thus the whole of the venous blood collected into one cavity, is forced by the muscular contraction of its walls into the right ventricle, *v, d,* and its return prevented by a valve placed at

the orifice of communication. The whole of the venous blood thus collected into the ventricle is forced by the muscular contraction of its walls into the pulmonary artery, *a, p,* by means of which it is conveyed to every part of the lungs. Whilst passing through these organs, *p, d, p, g,* it is exposed to the action of the air, and from being of a dark purplish or venous colour, it assumes a bright vermillion hue. It is now called arterial blood. In this state it is returned by the pulmonary veins to the left auricle, a small part only of which is seen in this engraving to the left of the pulmonary artery, and being expelled by this auricle into the left ventricle, *v, c,* it is by its powerful action propelled through the aorta *a, o,* and its numerous branches into every part of the body. Becoming altered in the tissues, the blood once more returns by means of the veins already described, to the right auricle of the heart, to travel over the same course, and to undergo the same process in the lungs. This is called the circulation of the blood: in man and in mammals and birds, it is double and complete, as is more fully explained in the text.

It may be further mentioned that the Plate gives an excellent view of the way in which the two great veins, the venæ cavæ, are formed, the superior chiefly by the venæ innominatæ, *v, s, g, v, s, d,* right and left; the inferior by the veins arising in the lower or subdiaphragmatic half of the body. The diaphragm, or midriff, here alluded to, is represented by the fine red line running across the body, immediately beneath the heart and lungs, in the Plate we now consider.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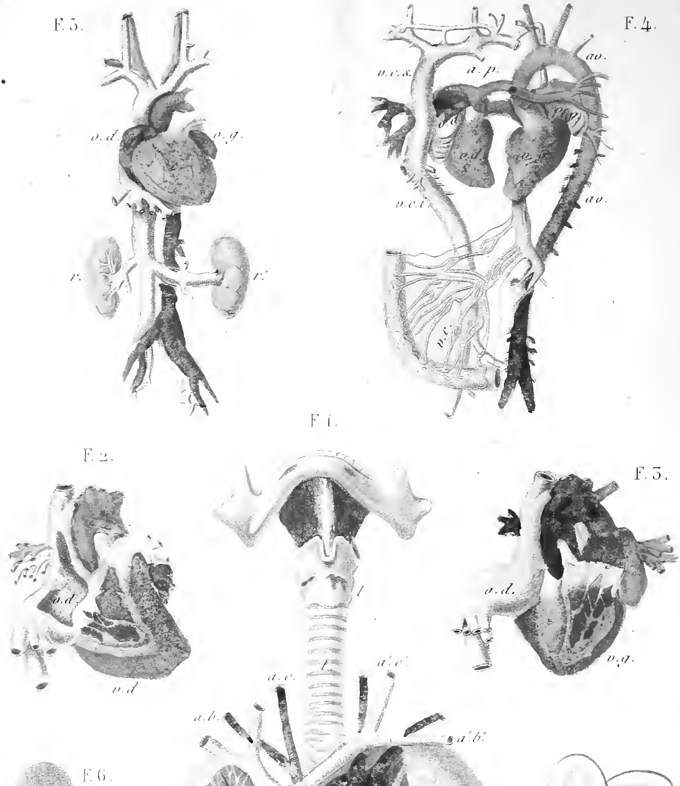

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EXPLANATION OF PLATE III.

The object of the Figures in this Plate is to explain still further the history of the circulation of the blood, the beauty of its mechanism, and its completeness as a mechanical contrivance.

Fig. 1 gives a view of the lower jaw; larynx, or organ of the voice; trachea, aspera arteria, or wind-pipe; right and left lung, partially dissected, so as to display, by the removal of the pericardium pleuræ, and sternum, or breast-bone, the heart and great blood-vessels *in situ.*

The lower jaw is not lettered in the engraving; it requires no explanation. Two strong muscles, besides many others which have been removed, connect it with the hyoid bones, which, by an oversight of the artist, have not been represented here. These hyoid bones are united by broad ligaments to the thyroid cartilage, the largest of the cartilages which form the larynx, *l.* The hyoid bones, together with the ligament connecting them to the thyroid cartilage, are carefully represented in Fig. 6, Pl. 4.

Continuous with the larynx, is the trachea, also marked *l;* a little lower down, the trachea divides into two branches, called bronchi, one to each lung; these divisions are not seen on this Figure, but a view of their posterior surface is represented in Pl. 4, Fig. 1.

The air descending through the mouth and nostrils passes into the pharynx, and next into the larynx, and from it, by the trachea and bronchial tubes, into both

lungs, *p, p*. The right lung, composed of three lobes, is marked *p*; the left lung, composed of only two lobes, is also marked *p*. They have been deeply dissected at the roots, in order to display the entrance and exit of the large blood-vessels. To understand these physiologically, we must return to the heart, following the veins of the body, sometimes called systemic, into the right auricle. The venous blood of the whole body, with the exception of the venous blood of the heart itself, is conveyed to the right auricle, *a, d*, by the two great veins called venæ cavæ; the inferior, *v, c, i*, and the superior, *v, c, s*. How the vena cava inferior is formed has been already explained; the formation of the vena cava superior is readily seen in the engraving: *a, b*, and *a, c*, marking the internal jugular and subclavian veins on the left side, which by their union form the left vena innominata; the two innominatæ form, by uniting, the vena cava superior. The blood, returning from the tissue of the heart itself, is returned to the right auricle by a separate vein, called the coronary. Thus, all the dark blood of the body is at last collected into the right auricle, and along with it, as has been already explained, the chyle.

The blood thus poured into the right auricle is as speedily driven from it, as it arrives, in successive portions; the muscular walls of the auricular cavity act upon its contents, driving the fluid mass into the right ventricle, *v, d*, and this hollow muscular cavity also contracting, forces the blood onwards towards and through the lungs by means of the pulmonary artery, *a, p*, which is called an artery, although it circulates only dark or venous

blood. The student may now trace this artery into the lungs, to each of which it sends one large branch. The vessels coloured red in the engraving are the pulmonary veins, represented as re-conveying the blood (now become arterial by being exposed to the influence of the atmospheric air) towards the left auricle, *o, g,* into which they enter. The blood, now arterialized, is forced by the left auricle into the left ventricle, *v, g,* from which it passes, strongly impelled by the muscular force of the ventricle, into the aorta, *a, o,* and, by means of the innumerable branches and ramifications of this great artery, into every part of the body. *a, b,* and *a, c,* point to two large branches of this artery, the right subclavian, and the right common or primitive carotid artery.

N.B. By an oversight of the artist, the pulmonary veins have been coloured pale blue instead of red, to signify that they carry arterial blood; but their course may be easily traced to the left auricle, *o, g* (oreillette gauche; left auricle), and the mistake thus rectified.

Fig. 2 represents the heart, with a portion of the large vessels, removed from its position and connections. It is laid on its posterior surface. The right auricle, *o, d* (oreillette droit), has been laid open anteriorly, as well as the right ventricle, with which it communicates by a large aperture called the right auriculo-ventricular orifice. In the entrance or passage is placed a valve, called triglochlin, or tricuspid, permitting the blood to pass readily from the auricle into the ventricle, but preventing regurgitation to any great extent. Connected with the right ventricle may be seen the pulmonary artery, also laid open, and two

of the three valves in the orifice (semi-lunar valves), represented in profile, slightly projecting into the cavity of the vessel. These valves permit the blood to pass onwards from the ventricle into the artery, but prevent its return into the ventricle.

The termination of the venæ cavæ, in the right auricle, and the arch of the aorta, are readily seen in this Figure.

Fig. 3. This Figure is intended to represent the interior of the left side of the heart, laid open so as to show the mechanism of the interior. *o, g,* is the left auricle laid open; the pulmonary veins may be seen entering it. These veins and this auricle contain only arterial blood. *v, g,* are placed near the left ventricle, which communicates by a large orifice with the left auricle, receiving from it the arterial blood coming fresh from the lungs.

In the entrance between the auricle and ventricle there is placed a valve called the mitral, whose function is to prevent the return of the blood from the ventricle into the auricle; the valve closes the passage temporarily, and the ventricle acting on the blood it contains, the fluid is thus strongly forced into the aorta, and by its means, and the numerous branches it gives off, the arterial blood is driven into all parts of the body. All these parts it nourishes, directly or indirectly; what remains is returned to the heart by means of the veins.

In this Figure, *a, o,* mark the aorta, which has been laid open at its commencement; at its point of junction with the left ventricle, three semi-lunar valves are found, as on the right side of the heart, and performing a similar function—namely, the preventing the blood which has

once entered the aorta from returning into the ventricle.

The letters *a, d,* mark the position of the right auricle, which in this preparation, together with the left ventricle, has been left unopened.

Fig. 4. This is an ideal Figure, intended to give a clearer view of the mechanism, and course of the double circulation of the blood, the pulmonary and the systemic. The heart is represented as forming two distinct hearts, which in reality it is, although mechanically united to each other. The right auricle and ventricle form one heart, the right; the left auricle and ventricle form another, the left. These two sides of the heart never communicate with each other after birth; prior to this they did, thus forming one of the many peculiarities of fœtal structure.

o, d, mark the right auricle of the heart, into which the venæ cavæ may be seen entering; *v, d,* the right ventricle of the heart, receiving the venous blood from the right auricle. Both cavities, by an oversight of the colourist, have been coloured light red instead of dark blue, to represent the nature of their contents. *a, p,* point to the pulmonary artery, arising from the right ventricle, and dividing into two branches, going to each lung.

o, g, point to the left auricle, receiving the arterial blood from the pulmonary veins, and transmitting it to the left ventricle, *v, g.* From this, the arterial blood passes into the aorta, *a, o,* by which it is distributed to all parts of the body, and to the substance of the heart itself.

To render the engraving still more instructive, the artist has placed on the Figure a portion of the small intestine,

showing how the lacteals arising from it terminate in the thoracic duct, which, as has been already said, enters the venous system near the point of union of the left subclavian and internal jugular veins. *v, c,* point to the lacteals; the upper portion of the thoracic duct has, in this Figure, by an oversight of the colourist, been coloured blue.

v, c, s, and *v, c, i,* mark the venæ cavæ.

Fig. 5. *o, d,* the right auricle, into which may be seen entering the venæ cavæ; *c,* the right ventricle, giving off the pulmonary artery; *o, g,* the left auricle; *r, r,* the kidneys, with the renal veins joining the vena cava inferior. There is a good view of the course of the aorta in this Figure.

Fig. 5 *bis.* A vein laid open to show the valves found in its interior; they permit the blood to flow towards the heart, but prevent its retrograding towards the parts from which they arise, thus securing the onward course of the blood towards the heart.

Fig. 6, 6, 6. Microscopic views of the globules of the blood.

EXPLANATION OF PLATE IV.

Figs. 1, 2, 3, 4, and 5, represent the posterior aspects of the organs engraved in Figs. 1, 2, 3, 4, and 5 of the preceding Plate (Pl. 3). A brief description will therefore suffice for these Figures.

Fig. 1. *l*, marks the back of the larynx; *t*, the posterior flattened surface of the trachea, or wind-pipe; *p*, the back of the right lung; *p'*, the left lung; *a, o*, the aorta; *a, b*, the left subclavian artery; *a', c'*, the left common carotid; *a, c*, the right common carotid; *a, b*, the right subclavian artery; *v, c, s*, the vena innominata of the right side, proceeding to form, with the left vena innominata, the vena cava superior; *v, c, i*, the vena cava inferior; *o, g*, the left auricle of the heart, receiving the pulmonary veins; *c*, the posterior surface of the left ventricle.

Fig. 2. The same structures as are represented in Fig. 2, Pl. 3, seen on their posterior surface. *o, d*, the right auricle of the heart; *c*, posterior surface of the ventricle; *a, p*, branches of the pulmonary artery, coloured red by an oversight of the colourist; *a, o*, the aorta.

Fig. 3 represents the same structures as are seen in Fig. 3, Pl. 3, but seen on their posterior surfaces; *o, g*, the left auricle; *v, p*, pulmonary veins; *a, o*, arch of the aorta; *c*, left ventricle.

Fig. 4. The posterior view of Fig. 4, Pl. 3. *o, v, s*, (*c* ?) *d*, superior vena cava; *o, d*, right auricle; *v, d*, right ventricle. From it may be seen (coloured red instead of blue) the pulmonary artery, sending a large branch to each lung. *o, g*, the left auricle; the right pulmonary vein may be seen entering it, but it is not lettered. *v, g*, the left ventricle; *a, o*, the aorta which springs from it; *v, c*, the lacteal or chyliferous vessels, arising from the mucous surface of the small intestine, and terminating in the thoracic duct, which in this Figure may

be traced to the left subclavian vein, in which it terminates.

Fig. 5. The posterior view of Fig. 5, Pl. 3. *c*, the left ventricle; *a, o*, the aorta; *r, r*, the kidneys (*reins*).

Fig. 6. The hyoid bones, thyro-hyoid ligament, and larynx, seen in profile; left side.

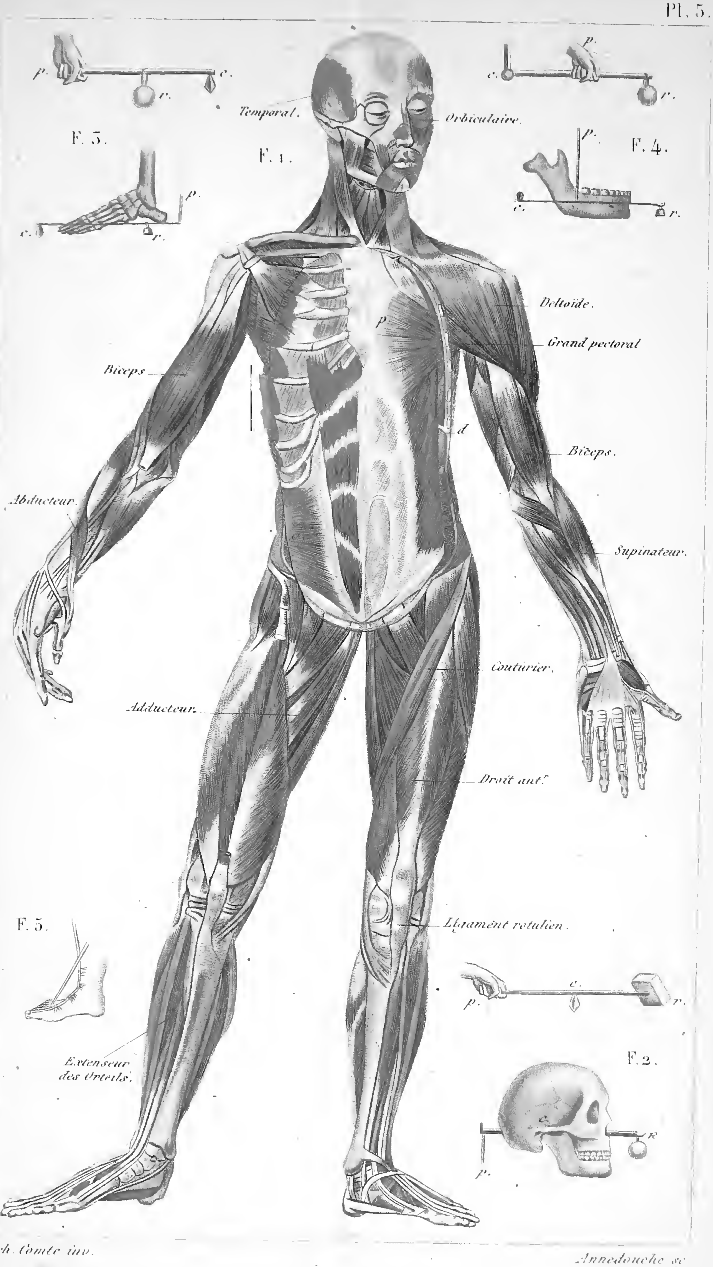
Fig. 7. The larynx, divided vertically, so as to display the interior of the organ of voice. The parts which are more prominently represented are the epiglottis, projecting upwards, and the ventricles of the larynx of one side. Above and below the little cavity, or hollow, lie the vocal cords of that side; the superior, namely, or false, and the inferior, or true vocal cords.

By the vibrations of these, the voice is formed. (See the Text.)

EXPLANATION OF PLATE V.

Fig. 1 represents the arrangement of the muscles as they exist in layers, attached to the bones, and connected with each other by sheaths of the connective or cellular tissue, and in the limbs by aponeurotic sheaths, which have been removed, in order to display the forms of the muscles. With the muscles are represented their tendinous attachments, which have been left uncoloured; also the annular ligaments, or retinacula, which bind down the tendons at the wrists, ankles, and instep.

A few of the names of the muscles are given on the



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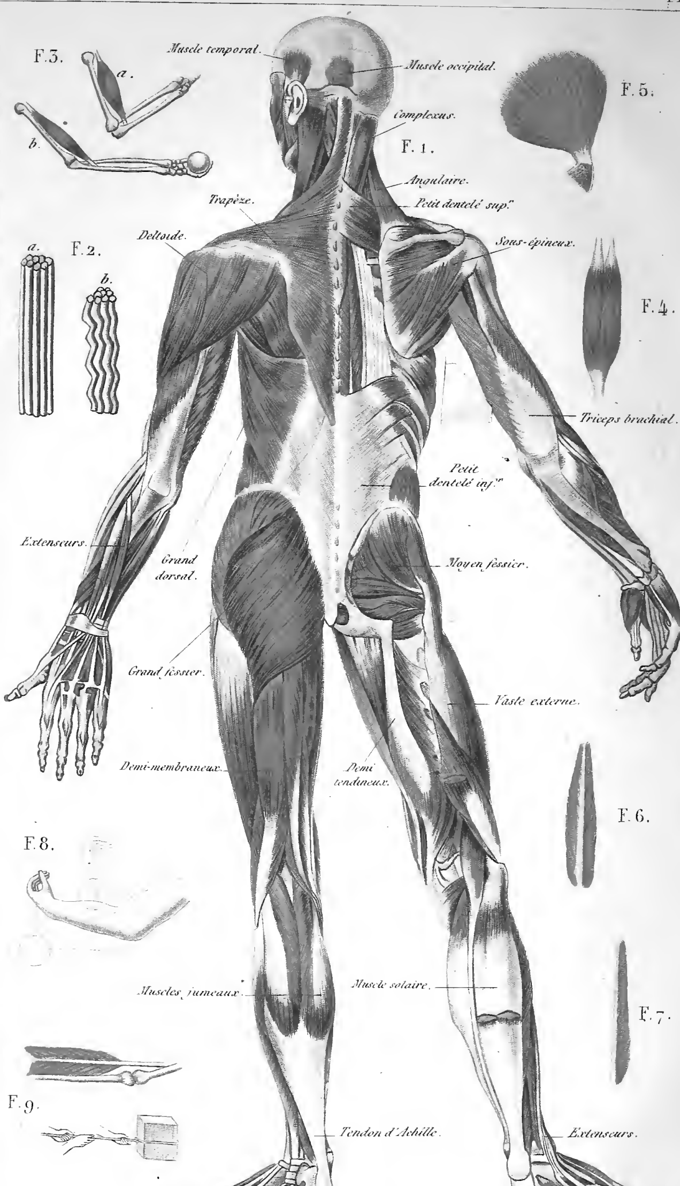
Annedouche sc.



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engraving in French; the translation of these names, proceeding from above downwards, is as follows:

The left represents the superficial layers of the muscles; on the right, the deep layers. I shall commence, therefore, with the left side of the Figure.

Orbiculaire . . .	Orbicular muscle of the eyelids.
Deltoide	Deltoid muscle.
Grande pectoral . .	Great pectoral.
Biceps	The biceps.
Supinateur . . .	The supinator longus.
Coutourier . . .	The sartorius.
Droit anterieur . .	Rectus femoris.
Ligament rotulier .	Ligament of the rotula, or patella.
Temporal	Temporal muscle.
Biceps	Biceps muscle.
Abducteur . . .	The long abductor muscle of the thigh.
Extenseur des orteils.	Common extensor of the toes.

Front.—d. Rectus abdominis of the right side.

o. Internal oblique muscle of the abdomen of the right side. The external oblique and abdominal aponeurosis are represented on the left side of the figure.

Now raise up the layer of the abdominal muscles, the sternum, anterior parts of the ribs and costal cartilages, and this will display:

p, p. The lungs *in situ.* *c.* The heart enclosed in the pericardium. *d.* The diaphragm or midriff. *c.* The stomach. *f.* The liver. *e. p.* The large omentum lying over and

obscuring the great mass of the small intestines. *i. a.* portion of the large intestine. 3. The fundus of the bladder. Fig. 2, 3, 4, and 5 of this plate have a reference to the different kinds of levers; this is fully explained in the text.

In this Plate are three figures not numbered by the author; the reader will find them described and referred to in the text.

EXPLANATION OF PLATE VI.

Figure 1. Muscles of the posterior aspect of the body.

Muscle temporal. . . .	Left temporal muscle.
Muscle occipital. . . .	Left occipital muscle.
Complexus.	Right conplexus.
Angulaire.	Levator anguli scapulæ.
Petit dentele supérieure. .	Serratus posticus superior.
Sous-épineux.	Infraspinatus muscle.
Triceps brachial. . . .	Triceps extensor brachii.
Trapeze.	Left trapezius muscle.
Deltoide.	Left deltoid muscle.
Extenseurs.	Extensors of the fingers.
Grand dorsal.	Latissimus dorsi.
Petit dentele inférieure. .	Serratus postius inferior.
Grand fessier.	Gluteus magnus, left side.

Semi-membraneux. . . .	Semi-membranosus, left side.
Muscles jumeaux. . . .	Gastro-cnemii muscles.
Tendon d'Achille. . . .	Tendo Achilles.
Moyen fessier.	Gluteus medius, right side.
Vaste externe.	Vastus externus, ,,
Demi-tendineux. . . .	Semi-tendinosus, ,,
Muscle solaire.	Soleus muscle, ,,

Upon it and crossing it diagonally may be seen the remarkable muscle called plantaris.

Extenseurs.	Extensors, right side.

Fig. 2 *bis*. Shews the form of the primitive fibres in bundles which compose the muscles.

Fig. 3 *bis*. The biceps shewn in its active and comparatively passive states, to shew the extent of its powers of contraction or shortening itself, by which means the forearm is flexed on the arm, or *vice versa*.

Fig. 4. The biceps separated from its connections with the bones thus displaying its form.

Fig. 5. Another muscle dissected from its attachments to shew its form.

Fig. 6. This muscle also removed from its attachments shews what is meant by a complete penniform muscle; whilst Fig. 7, represents a semi-penniform muscle.

Fig. 8. Diagram and outline of a part of the arm and forearm and hand to explain the action of the flexors of the forearm.

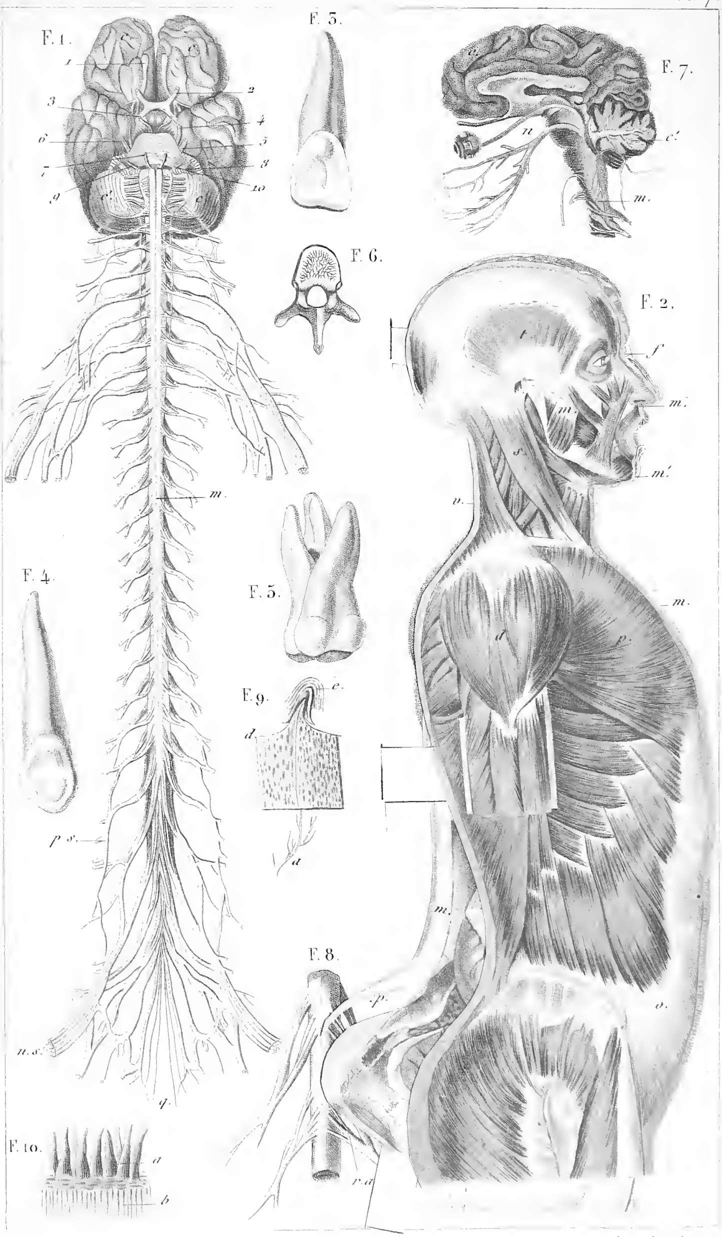
Fig. 9 *bis*. The upper of these two figures shews a complete penniform muscle in action. The lower is intended to shew the effects of traction on a cube.

EXPLANATION OF PLATE VII.

Fig. 1. The cerebro spinal axis, that is the brain and spinal marrow with the nerves directly connected with them, removed from the osseous case which contained them. The fibrous connecting membrane called the dura mater has also been removed.

These organs are usually called the central organs of the nervous system.

c, c. The brain or cerebrum proper; inferior surface. The letters are placed on the lower surface of the anterior lobes of the brain. *c'.* Cerebellum or little brain, the middle portion of which is concealed by the commencement of the spinal marrow. *m.* Spinal marrow; medulla spinalis. 1. Olfactory or first pair of nerves; these proceed to the nose. 2. Second pair of nerves called optic; after decussating they proceed to the eyes. 3. Third pair of nerves proceeding to the motor muscles of the eyes. 4. Fourth pair of nerves called also pathetic; these supply the superior oblique muscle of the eye. 5. Fifth pair of nerves, or trifacial; these proceed to the integuments of the face, to the eyebrows, cheeks, teeth and tongue. This is a double pair of nerves, being both motor and sentient. The posterior root has a ganglion upon it, so that it strongly resembles one of the spinal nerves. A branch of it supplies the tongue, and is considered as the gustatory nerve especially, so that the nerve in every sense is important and complex. 6. The sixth pair of nerves, supplying



Ach. Comte inv.

Annedouche sc.

the abductor muscle of the eye-ball. 7. Nerves of the seventh pair called also facial. It is formed of two portions on each side, the portis dura and portis mollis. The portio dura is a motor nerve, and supplies the muscles of expression of the face. The portis mollis or auditory portion penetrates into the internal ear and forms the auditory nerve. 8. Usually called the eighth pair of nerves, but in reality composed on either side of three nerves, to a certain extent distinct from each other. The first of these is called the glosso-pharyngeal: it supplies the tongue and pharynx; the second is the nervus vagus which proceeds to the larynx, lungs, and stomach, and is perhaps the most important and the most remarkable nerve, or pair of nerves in the body; the third is the spinal accessory or nerve proceeding chiefly to the trapezius muscle of the neck. 9. The hypoglossal or lingual nerves, the motor nerves of the tongue. These are the nerves usually called cerebral or cranial nerves.

The remaining nerves seen in the figure are the spinal nerves, named from the regions they occupy, and reckoned from above downwards. Thus the nerves immediately following the brain are called the cervical pairs of spinal nerves, first, second, third, &c. Those which follow are the dorsal, and next to these the lumbar and sacral. The lowermost cervical and first dorsal unite to form a plexus which is represented in the figure, whilst lower down is the lumbo-sacral plexus formed by branches of the lumbar and sacral nerves; *p, s,* and *n, s,* mark this extensive plexus. *m.* The anterior surface of the spinal marrow. 10. The terminating *filum* of the spinal marrow which pro-

apex of the heart concealed by the pericardium enclosing it; *e*, the stomach; *c, t*, the transverse arch of the colon; *c, d*, the descending colon; *i*, the small intestines.

4. The next layer following the one just described is one representing merely the brain; *c*, marks the right hemisphere of the brain; the reverse of this layer represents a vertical section of the brain, or cerebrum proper; the cerebellum or little brain, and the medulla oblongata. The engraving shews distinctly the different characters of the various parts of the encephalic mass, and the varying arrangement of the cortical and medullary portions, and of the course of the medullary fibres.

5. On raising up this segment or layer, there remains but one which I shall now describe. It represents the osseous and muscular structures which support the viscera seen in the other layers, divided vertically, as regards the head and spine, and pelvis, but left entire as regards the chest and abdomen.

c. The interior of the left side of the cranium; *f*, placed a little below the frontal sinuses; *b*, the nasal fossæ covered by the pituitary membrane; *m*, section of the osseous palate; *t*, position of the pharynx; *m'*, section of the symphysis of the chin. The large muscle with diverging fibres attached to it by the apex, and by its broad basis to the tongue is the genio glossus of the right side; *v, v'*, the interior of the spinal canal: the long series of openings seen in it are the foramina intervertebralia giving passage to the spinal nerves; *m*, the sternum. Inferiorly is the abdomen enclosed by the abdominal muscles; the viscera have been removed so that these muscles belong to the

left side, and are represented here as being seen internally, and on their concave or visceral surface.

Fig. 3, 4 and 5, represent, an incisive tooth, 3 ; a canine tooth, 4 ; and a molar tooth 5.

Fig. 6, represents a vertebra, as seen vertically.

Fig. 7, represents a vertical section of the brain, and so disposed as to shew, *c*, the convolutions of the right hemisphere ; *c'*, the interior of the cerebellum ; *n*, the optic nerve on its way to the eye-ball. Below the letter *n*, is the fifth pair of nerves, called trifacial. This is the great nerve supplying the surface of the face with sensibility ; the muscles of the lower jaw with their motor power ; the tongue with the sense of taste ; and further by branches distributed to the other organs of sense, and more especially to the eye and nose, exercising a powerful influence over their functions ; *m*, points to the spinal accessory nerve, and to the other divisions of the eighth pair of cranial nerves, namely, the glosso-pharyngeal and pneumogastric.

Fig. 8. A segment of the spinal marrow intended to display the mode of origin of the spinal nerves. The nerves may be seen arising in pairs, and by two sets of roots, an anterior, *r*, *a* ; and a posterior, *r*, *p*. On the posterior roots only is placed a ganglion. It is now generally admitted that the posterior roots are those by which sensations are transmitted to the spinal marrow and brain, and that by the anterior roots the will exercises over the muscles the power of motion.

Fig. 9. The apparatus constituting the tactile sense in man. *a*. Nervous filament entering the dermis or true

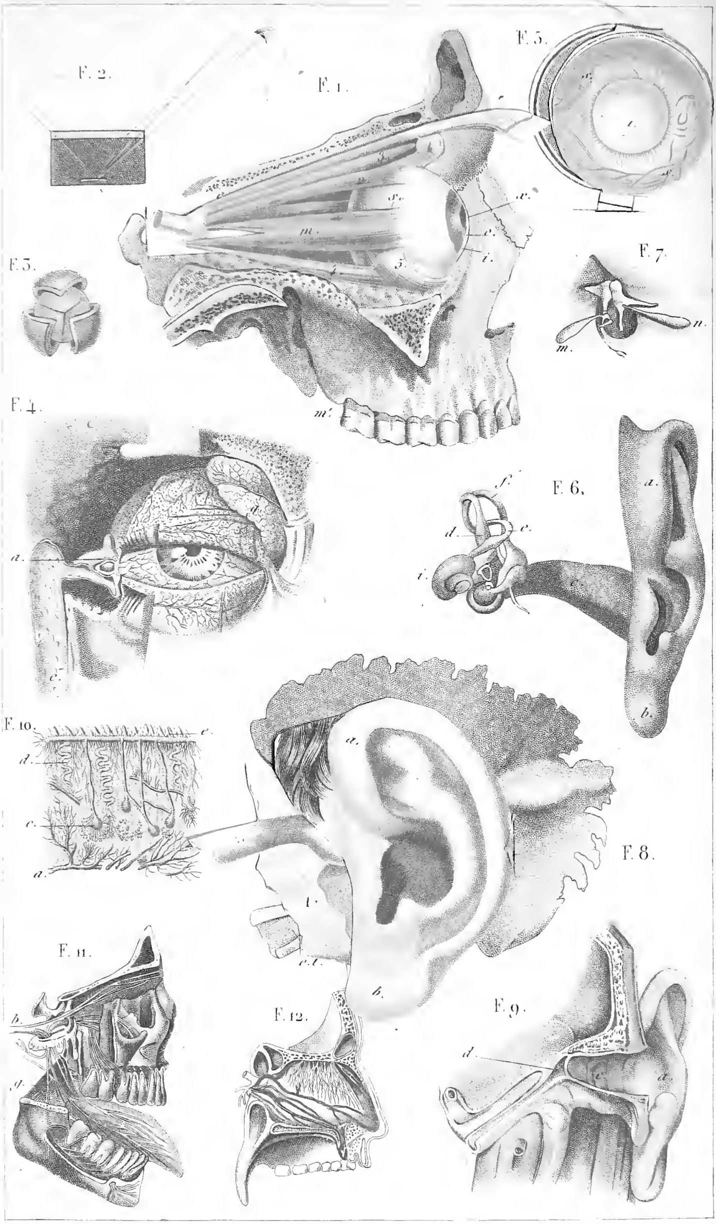
skin; *d,* neurilemma furnished by the dermis; *e,* layer more or less thick of the horny or epidermic substance, the organ of protection.

Fig. 10. *a.* Groups of the nervous papillæ as seen under the microscope; *b,* the dermis or true skin. These are best made out on the tactile extremities of the fingers and toes.

EXPLANATION OF PLATE VIII.

Fig. 1, represents the right eye-ball *in situ,* together with the muscles of the orbit as they are usually called.

m'. Right superior maxillary bone forming the greater part of the right side of the upper jaw. 2. Rectus superior muscle of the eye-ball. *m.* Rectus externus. 4. Rectus inferior. These muscles to which must be added a fourth, the rectus internus, seen in the plate, but not lettered, move the eye-ball in all directions, when acting separately or combined. 3. The superior oblique or trochleator muscle, so called in consequence of its tendon passing through a pulley. 5. Inferior oblique muscle. These six muscles exclusively belong to the eye-ball; another muscle has been represented in this figure which has not been lettered: it is the levator palpebræ superioris, the muscle which raises the upper eyelid. It extends considerably beyond the others, and has no connection with the eye-ball. *s.* The eye-ball itself; the letter is placed upon the sclerotic tunic, the outer investing membrane of



Ach. Comte inv. *Annedouche sc.*

the eye-ball. By raising up this layer, on its *reverse,* will be seen the passage of the optic nerve, into the interior of the eye-ball; *n, o,* optic nerve; *r,* the retina, that is the nervous membrane in which the optic nerve terminates; *e,* the crystalline humor or lens.

The layer next in succession represents, in some respects, a deeper dissection. The muscles of the orbit and eye-ball have been removed. *e.* The superior wall of the orbit; *œ* and *c'* mark the layers or tunics composing the eye-ball, and which successively and from without inwards are: the sclerotic, choroid and retina; *r,* the interior of the eye-ball; the space occupied by the vitreous humor; *æ,* the crystalline humor or lens; *c,* the cornea; *i,* the iris. The dark space between the iris and the cornea represents the anterior chamber of the aqueous humor.

Fig. 2. Shews the effects of the reflection of the luminous rays.

Fig. 3. The crystalline humor or lens, partially dissected.

Fig. 4. Represents the lachrymal apparatus; *g,* the lachrymal gland; *a,* the puncta lachrymalia; *c,* the nasal canal or duct.

Fig. 5, represents the superposition, from before backwards, of the various transparent membranes which the light traverses on its way to the retina *b,* on which the figure of the object is impressed. The figure also represents the opaque laminæ of the eye-ball.

1. The transparent cornea; *s, s,* the sclerotic. On the *reverse* of this layer are seen the ciliary processes and choroid with their continuation, the iris, which is not lettered.

In the centre of the iris is *p*, the pupillary foramen or aperture through which the rays of light pass after having traversed the cornea and aqueous humor. The rays of light now reach the capsule of the lens and lens itself, both of which are transparent, and through which, of course, the rays penetrate. They next reach the capsule of the vitreous humor, and the vitreous humor itself, which being likewise transparent, permit them to reach, 5, 5, the retina, modified in their course, but not decomposed. The concave surface of the retina is represented on the interior surface of the second layer, 5, 5, and in its centre may be seen the *foramen* of *Sœmmering*. The reverse of this layer merely shews the retina under another aspect.

Now raise this up and examine the deepest layer. It gives a view of the concave surface of the posterior half of the retina *b*; on it are placed two vessels; the foramen centrale retinæ, or foramen of Sœmmering, and the entrance of the optic nerve.

Fig. 6. Shews the external ear *a*, the middle ear *c*, and the internal ear *i*, in all their natural relations. The internal ear is composed of the three semicircular canals, *d*, *e*, *f*, which surmount the cochlea and the ossicula auditus.

N.B. The small bones of the ear, the *ossicula auditus*, belong to the middle ear and are lodged in the cavity of the tympanum.

The letter *c* is placed on the meatus externus, the tube connecting the external ear to the middle ear, but this tube does not belong to the middle ear.

Fig. 7. Shews the small bones of the ear in their relation to the membrane of the tympanum, usually called the drum of the ear, whose tension and relaxation they cause, according as they are acted on by the muscles *m* and *n*. These muscles are named the tensor and laxator tympani.

Fig. 8. The portion of the apparatus of hearing composed of the concha or external ear *a, b,* and of the middle ear; *l,* the glenoid cavity for the reception of the condyle of the lower jaw; *m, n,* the tensor and laxator tympani muscles connected with the small bones of the tympanum; *e, t,* the Eustachian tube connecting the tympanic cavity with the pharynx. The small bones seen here, but still more distinctly in Fig. 7, are the malleus, incus, orbicular bone and stapes. They form an irregular chain of bones extending across the tympanum from the tympanic side of the membrana tympani to the *foramen ovale* leading into the vestibule, into which the base of the stapes, or stirrup-shaped bone is inserted. The vestibule is the central portion of the deep or internal ear. It seems to constitute, with its contents, the essential part of the organ of hearing, being that which is the last to disappear in descending the scale of animal life.

Fig. 9. Represents the relations of the different parts of the organ of hearing, composed by means of a figure which displays, from before backwards, the concha, *a*; the external auditory canal, *c*; the tympanic cavity, *d*. The deep ear is not in view, but it immediately follows the tympanic cavity.

Fig. 10. A section of the human integuments, as seen

under the microscope; *a,* blood-vessels entering the dermis or true skin; *c,* sebaceous glands; *d,* sudoriferous glands, with their twisted or convoluted ducts; *e,* organ containing the colouring matter, surmounted by the papillæ.

Fig. 11. Intended to shew the distribution of the fifth pair, or trifacial nerves; *b,* marks this complex double rooted nerve soon after leaving the cerebral structure; *g,* the lingual branch supplying the tongue, and generally admitted to be the nerve of taste. Its branches may be seen penetrating into the orbit, and supplying the teeth in the upper and lower jaws. It may be viewed as the type of the double rooted nerves, but it is still more complex than the spinal nerves.

Fig. 12. Shews the nerves distributed to the pituitary membrane of the septum of the nasal fossæ of the left side. The branches of the olfactory nerve are more immediately the object of the figure; they may be seen descending vertically on the septum or partition separating the nostrils into two great cavities, a right and left.

To render the Atlas to which the above descriptions refer, complete, as a brief system of human anatomy, the publisher, M. Baillière, has by my advice, added wood engravings of the skeleton, the arterial and the nervous system.

In this place, I purpose giving a brief view of the anatomy of these three important systems of organs,

which render the Atlas still more useful to those who study it with a view of acquiring an analytical and synthetical knowledge of the human frame.

1. The student of human anatomy is expected to commence his studies with the skeleton (see Pl. IX, X, XI). In some respects, and for reasons which could readily be given, it is necessary for him to do so; yet the method is not analytical, but synthetical, and simply mechanical. It leads occasionally, and in some minds, to serious physiological errors, and in all respects is the reverse of the analytical. But it is also to be remembered that the skeleton forms the framework of the body; that it supports most of the organs, mechanically; that it determines the proportions of the limbs and torso; that it constitutes the levers by means of which the muscles perform the various movements connected with locomotion; and, lastly, constitutes the leading feature by which one grand division of the animal kingdom is known.

The vertebral column, forming the essence of the skeleton, gives rise to the term vertebrata (animalia), to which class man himself belongs.

The assemblage of bones constituting, as it were, the framework of the body, is called the skeleton; nevertheless, in preparing it for exhibition in museums, some parts are preserved with it which, strictly speaking, do not belong to it: such as the teeth, which are not bones, and form no part of the skeleton; whilst the lingual, or hyoid bones, supporting the tongue and the organ of voice, are omitted.

The bones are, as every one knows, hard compact organs of various forms, and very numerous. The osseous

tissue composing them consists essentially of a cartilaginous or animal basis, and of phosphate of lime; to these must be added, blood-vessels, and even nerves, for the bones are alive and organized, in the strictest sense of the term. They are connected together by ligaments of various kinds, and most of their extremities are protected against the evil effects of friction by cartilages incrusting their extremities, and still further by a pouch or bag, termed synovial. The synovia is a kind of joint-oil secreted by these pouches or bags, and found in all the moveable articulations.

It is usual to divide the skeleton into—1. bones of the trunk; 2. bones of the extremities. This method is wholly mechanical, and behind the philosophical knowledge of the day.

A much preferable method is to view the skeleton as composed of a vertebral column and its appendages. The vertebral column may be considered as formed of a chain of bones, called vertebræ, which are thus classified:

	Names.	Number of separate bones.
Regions.*	1. Cranial vertebræ . .	3 ? Number uncertain.
	2. Cervical "	7
	3. Dorsal "	12
	4. Lumbar "	5
	5. Sacral "	5
	6. Coccygeal "	4

* All these vertebræ are reckoned numerically, from above downwards.

1. APPENDAGES.

Names.	Numbers.
1. The jaws or maxillæ: upper jaw	11
„ „ lower „	1
2. Lingual, or hyoid bones	5
3. Ribs; divided into—true, 7; false, 5: 12 on each side	24

2. LIMBS.

1. Superior or thoracic extremities:

Names.	Numbers.
a. Shoulder	2; scapula, clavicle.
b. Arm	1; humerus.
c. Fore-arm	2; radius, ulna.
d. Hand:	
Carpus	8.*
Metacarpus	5.
Fingers	14.

2. Lower extremities:

a. Pelvis	2; ossa innominata, sacrum, coccyx.
b. Thigh	1; femur.
c. Leg	2; tibia, fibula.
d. Foot:	
Tarsus	7.†
Metatarsus	5.
Toes	14.

* First row: scaphoid, semilunar, multangular, pisiform. Second row: trapezium, trapezoides, magnum, unciform.

† Os calcis, or heel-bone; astragalus; scaphoid, or navicular; three cuneiform bones; cuboid. Total, 7.

In addition to the bones just enumerated, we have in the human skeleton:

1. The sternum, or breast-bone, a chain of bones whose relation to the rest of the skeleton has not as yet been well determined.

2. The sesamoid bones, of which the most remarkable are the patellæ, covering and protecting the knee-joint.

Skeleton of the Head.—The chain of vertebræ, with their appendages, composing the skeleton of the head, merit from their important relations to the brain and organs of sense, a special enumeration. In the cranium, properly so called, the following bones a reenumerated: 1. the frontal; 2. the two parietal bones; 3. the occipital; 4. the two temporal; 5. the sphenoid; 6. the ethmoid. In the face we find: 1. the two superior maxillary bones; 2. the two palatal bones; 3. the two molar; 4. two lachrymal; 5. two turbinated bones; 6. the vomer. In the lower jaw, one bone: the inferior maxillary.

To enable the animal to use these bones as levers, they are articulated or connected together by ligaments, and to the bones themselves are attached the living muscles by tendons. Thus the levers may be broken or fixed at the will of the individual, and in an instant. In the text will be found a more detailed account of this interesting system of organs.

II. Nervous System, (see Pl. XII.)

The engraving gives a view of the cerebro-spinal system, and the nerves more immediately connected with it. The

view is given as if the skull-cap and posterior wall of the spinal column had been removed, together with whatever of the soft parts might obstruct the view of the nerves themselves proceeding mostly to the muscles and integuments. This system is, to a great extent, distinct from the ganglionic which I have described in the text.

a. The brain, or cerebrum.
b. The little brain, or cerebellum.
c. Spinal marrow.
d. Facial nerve.
e. Brachial plexus, caused by the union of several nerves coming from (or proceeding to, as some think) the spinal marrow.
f. Median nerve.
g. Cubital nerve.
h. Internal cutaneous nerve of the arm.
i. Radial and musculo-cutaneous nerve of the arm.
j. Intercostal nerves.
k. Femoral plexus.
l. Sciatic plexus.
m. Tibial nerve.
n. External peroneal nerve.
o. External saphenous nerve.

III. The Vascular System, (see Pl. XIII.)

A wood engraving of the arterial system, this being the system of vessels, by means of which the blood, out of which, no doubt, all the organs are nourished, is conveyed to them.

All the viscera have been removed, leaving the arteries alone; the system commences with the aorta, as it appears where it springs from the heart; the arch it forms may be readily recognized, and in succession all the great branches it sends off to the trunk and to the limbs. In these vessels the course of the blood is always from the heart towards the extremities. They carry only arterial blood. These are the vessels which the surgeon so much dreads during serious operations, for, on being opened, the larger trunks, at least, require to be secured with ligatures. When punctured, their walls do not heal like the veins, and the vessel becomes obliterated.

Notwithstanding the great complexity of the human frame, and the number of organs of which it is composed, their relations and functions, or uses may be readily comprehended and understood, provided the structure be viewed physiologically. A knowledge of the external world and the objects it contains, is the grand object of man's formation as an animal. This knowledge he obtains by means of the organs of sense; the impressions on these are transmitted to the brain and spinal marrow by nerves; they therein become perceptions, and hence arise reflection, and reaction on the external world. Thus, one series of organs follows another by a kind of necessary relation or corelation strongly resembling cause and effect, although it be not so in reality, as thus:

1. Perception and knowledge of the external world, by means of—

Organs of sense.
Nerves of sensation.
Brain and spinal marrow.

2. Reaction on the external world, by means of—

Nerves of motion.
Muscles; active organs of locomotion.
Bones; passive " "
Articulations " "

3. Support or nourishment of the individual: conversion of the food into arterial blood, by means of—

1. Mastication.
Insalivation.
Deglutition.
Stomachal digestion.
Intestinal "
Absorption of the chyle.

4. Purification of the chyle; and 5, arterialization of the blood, by means of—

1. Secretions and excretions.

Organs: Liver, pancreas, kidneys, mucous glands, skin, lungs, &c.

2. Respiration.

Organs: The lungs.

6. Continuance of life on the globe, and of the various species, and natural families of animals: by means of—

Reproduction.

Organs: The organs of reproduction.

PLATE IX.

PLATE IX.

SKELETON VIEWED IN FRONT.

A. Frontal bone.
B. Left parietal bone.
C. Left temporal bone.
D. Superior maxillary bones.
E. Inferior maxillary bone.
F. Cervical vertebræ.
G. Left collar bone.
H. Placed between the left scapula and humerus of the same side.
I. Sternum, or breast-bone.
J. Right humerus.
M. Right radius.
N. Right ulna.
O. Right carpal bones.
P. Right metacarpal bones.
K. Lumbar vertebræ.
L. Left os innominatum, or nameless bone.
R. Left femur, or thigh-bone.
S. Left patella.
T. Left fibula.
U. Left tibia,
V. Right tarsal bones.
W. Right metatarsal bones.
X. Right phalanges of the toes.

PLATE X.

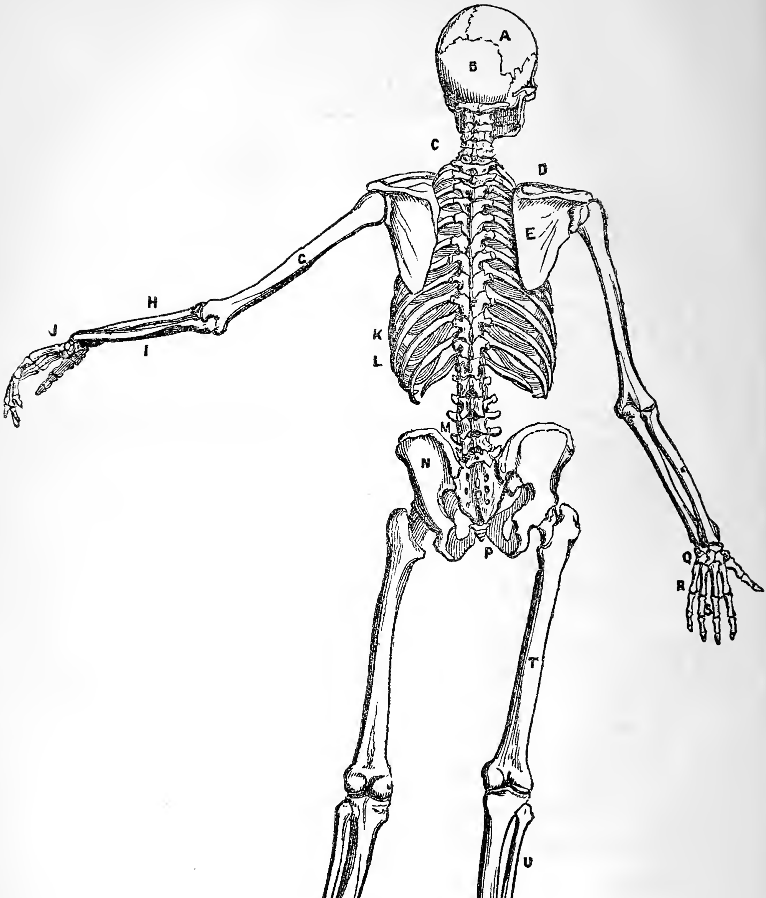


PLATE X.

THE HUMAN SKELETON; BACK VIEW.

A. Right parietal bone.
B. Occipital bone.
C. Points to the cervical vertebræ.
D. Right clavicle, or collar-bone.
E. Right scapula, or shoulder blade-bone.
G. Left humerus, or arm-bone.
H. The radius bone.
I. The ulna, or cubit.
J. The carpal bones, followed by the metacarpal bones and the phalanges of the fingers.
K. and L. The ribs and cartilages of the left side.
M. The lumbar vertebræ.
N. The left os innominatum, or nameless bone; these nameless bones, together with the sacral and coccygeal vertebræ, form the pelvis, or basin; P. is placed near the portion of the nameless bone called pubic.
Q. Right carpal bones.
R. Metacarpal bones.
S. Phalanges of the fingers.
T. Right femur, or thigh-bone.
U. Right Fibula, or perone.
V. Right tibia.
W. Left tarsal bones.
X. Left metatarsal bones.
Y. Phalanges of the toes.

PLATE XI.

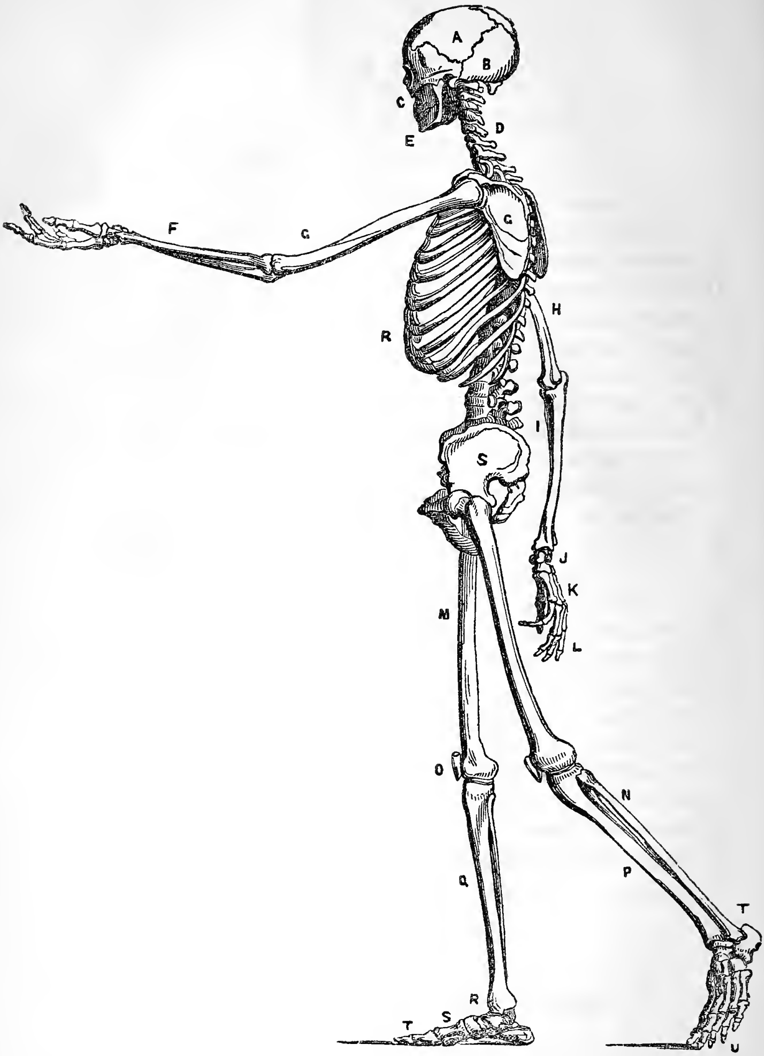


PLATE XI.

THE SKELETON VIEWED IN PROFILE.

A. Left parietal bone.
B. Occipital bone.
C. Points to the upper jaw.
E. Points to the lower jaw.
D. Cervical vertebræ.
C. Left scapula.
F. Left radius bone.
G. Left humerus, or arm-bone.
H. Right humerus.
I. Right cubit, or ulna.
J. Right carpal bones.
K. Right metacarpal bones.
L. Phalanges of the fingers.
M. Right fémur.
O. Right patella, or rotula.
Q. Right tibia.
R. Right tarsal bones.
S. Right metatarsal bones.
T. Right phalanges of the toes.
N. Left fibula.
P. Left tibia.
U. Phalanges of the left foot.
R. Cartilages of the false ribs.
S. Left nameless bone.
T. Left os calcis, or heel-bone.

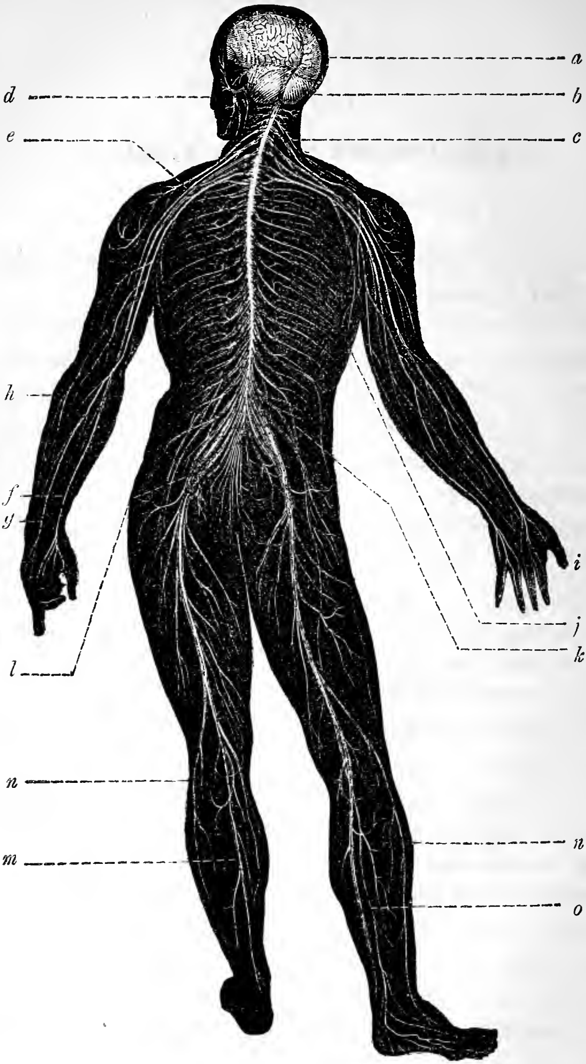


PLATE XII.—Nervous System, pp. 30—41.

EXPLANATION OF PLATE XII.

NERVOUS SYSTEM IN MAN.

(*For a description of the Nervous System, see Chap. IV., Part I. from p.* 30—41.)

The object of this beautiful and comprehensive engraving is to give at a glance a complete view of the cerebro-spinal axis, and of the spinal nerves of sensation and motion. To display the nervous system in this manner, the skull cap requires to be removed, and with it nearly the occipital bone: next, all the back part of the vertebral column and the cranial and spinal portions of the dura mater. By a deep dissection, most of the nerves may be thus exposed.

The sympathetic system of nerves are not displayed in a view of this kind, which, indeed, refers more especially to that great division of the nervous system supplying the integuments and muscles, over which, in a natural state, man exercises full control.

a. The brain or cerebrum proper. The letter points to the right hemisphere, between which and the left hemisphere, the inter-hemispherical fissure is distinctly visible. The back part of the hemispheres of the brain or cerebrum is usually called the posterior lobes of the brain. They overlap and conceal, as it were from view, when examined from above, the cerebellum or little brain, *b*; and this circumstance forms, no doubt, a remarkable circumstance in

the configuration of the human encephalon. Between the cerebellum and cerebrum may be seen in the engraving a fissure marking the position of the transverse septum or partition, a process of the dura mater or fibrous membrane of the brain, and on which process the posterior lobes of the brain rest.

c. The spinal marrow or medulla spinalis.

d. The facial nerve, the nerve of expression. Distributed to the muscles of the face, this fact, no doubt, induced the artist to give it a place in this engraving. Over the muscles to which it is distributed, man possesses great control, but their actions like all others of the body are not always obedient to his will. *e.* Brachial plexus formed by the union of several nerves coming from the spinal marrow. These nerves are the 5th, 6th, 7th, and 8th pairs of cervico-spinal nerves, and the 1st pair of dorso-spinal nerves. From this plexus arise the nerves supplying the superior or pectoral extremities such as *f,* the mediam nerve; *g,* the cubital nerve; *h,* internal cutaneous nerve of the arm; *i,* radial and musculo-cutaneous nerve of the arm.

The intercostal nerves—*j,* and the lumbar which follow them, seem to belong to the same system of nerves. The former supply the intercostal muscles, and the latter, those broad abdominal muscles, which form so large a portion of the abdominal walls. They have all sympathies, more or less deep, with the functions of respiration, and with that regular and rythmic action, on which respiration and life itself depends. When the vital function of respiration is interfered with, many other muscles are called suddenly and instinctively into action, thus shewing how extensive the

sympathies are, which connect the spinal nerves and muscles with the pneumo-gastric nerves.

In connection with the lower extremities, we have—*k*, the femoral plexus; *l*, the sciatic plexus; *m*, the tibial nerve; *n*, external peroneal nerve; *o*, external saphenous nerve. These, and many others, supply the integument of the haunches and lower extremities with sensibility, and the muscles with their motive power.

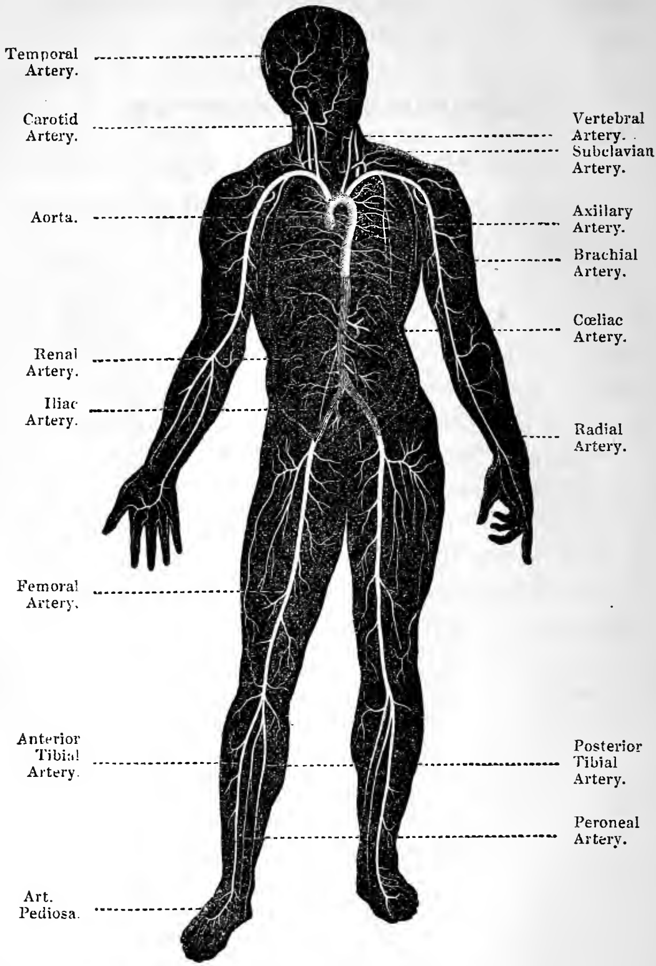


PLATE XIII.—Arterial System in Man, page 118.

EXPLANATION OF PLATE XIII.

ARTERIAL SYSTEM IN MAN.

(*See Chap. IV., Part II. p.* 118.)

The object of this engraving is to shew at a glance the mode of distribution of all the more important arteries of the human body, with the exception of the pulmonary artery, which, as has been already explained, does not carry *arterial,* but *venous* blood. In fact, it displays the whole course of the aorta, and of all the branches springing from it. No such dissection is ever made, nor is it necessary; but an ideal view like the present, is one of great value to those who may not frequently have dissected the great arteries of the body. At p. 119 of the text, will be found an enumeration of all the great arteries, arising from the aorta, as seen in this engraving. The position of the aorta itself as regards the viscera of the thorax and the abdomen, may be best understood by a reference to Plate 2.

MAN;

HIS

STRUCTURE AND PHYSIOLOGY.

PART I.

CHAPTER I.

The *beings,* or *bodies,* composing the Globe have been divided by scientific men into the inorganic and the organic, or organized; the latter alone live, the former merely exist. Carl Linné, an illustrious Swedish naturalist, arranged all that exists into three kingdoms, to which he gave the names of mineral, vegetable, and animal kingdoms. More lately, it has been proposed to view all nature as composed but of two kingdoms, namely, the organized and the inorganized, or mineral. This arrangement has been proposed in consequence of the difficulty met with in rigorously defining the animal and vegetable kingdoms.

At the head of all that lives, or seemingly has lived, stands Man, whose structure and functions it is the object of this little Work to describe and explain. But as Man forms also a portion of the animal kingdom, it will be

proper to make a few remarks in respect of it, as preliminary to those details which concern him alone.

It may be readily admitted, with a most distinguished botanist, M. de Candolle, that animals and vegetables in many points, though distinct, yet strongly resemble each other. The beings of both kingdoms live, breathe, grow by intussusception, are born, and die. Whilst alive, both strongly resist putrefaction; in both are found substances which chemistry, however refined, cannot produce by synthesis; in both kingdoms the laws of reproduction present a striking analogy—both reproduce individuals which, resembling their parents, constitute a species.

But if we examine into the chemical composition of the two kingdoms, we shall find some remarkable differences. Both, it is true, have an areolar or laminated tissue; transpirations and expirations; but the tissue of the vegetable is simple, compared with the animal tissue, as if in this latter kingdom the functions and organs had a constant tendency to become more and more specialized. Plants absorb the materials of their growth by means of their leaves and roots; animals through the medium of an internal cavity, and of vessels, which Hippocrates happily compared to internal roots: "As the earth is to plants, so the stomach is to animals."

Generally speaking, animals transport themselves readily from place to place, and this faculty of locomotion, when present, which is not always the case, is essentially an animal function. Let us imagine for a moment what would have become of the animal world, had vast trees, the giants of the forest, possessed the power of locomotion,

and been able to move with animal rapidity over the surface of the earth!

As regards species, animals seem to be superior in this respect to plants; there is scarcely a plant which has not some insect peculiar, as it were, to itself. The sea, which nourishes so few vegetables, abounds with animal life; and if, in the reproduction of the species, some plants are most remarkable in respect of fœcundity, the same may be said of some animals. The perch lays 300,000 eggs, the sturgeon more than 7,000,000.

Evaluations, which can be viewed only as approximations, raise the number of species of plants to 100,000 distinct species. As regards animals, the number of species of the class Mammals may be about 800; of Birds, about 6,000; of Fishes, about the same number; these, with 3,000 Reptiles, comprise the class vertebrata,* or animals which have a vertebral column. Of those which, being without such a column, have been called avertebrate, or *avertebrata,*† the Molluscs alone have never been, and cannot, for obvious reasons, be enumerated; and the same remark applies to Zoophytes, Parasites, &c. Some have estimated the whole at 2,000,000 of species, including the microscopic world, whose boundaries enlarge daily, with the improvement of the micro-

* Vertebrata animalia: animals whose skeleton is characterized by a vertebral column—that is, a chain of bones called vertebræ. This chain, or column, forms what in common language (extremely incorrectly) is termed the back bone.

† Avertebrata: animals without a vertebral column; the *a* of the Greek, used as a prefix, has a privitive quality.

scope itself. So infinite and so varied is that animal world of which Man forms a part.

Various systems of classification have been proposed; here it may suffice to say, that the vertebral kingdom, to which Man belongs, is usually subdivided into Mammals, Birds, Reptiles, and Fishes.

Of the various forms of animal life, the most interesting, unquestionably, to man, is that form which possesses a distinct skeleton, or internal framework of bones, articulated with each other. Of this framework, or internal skeleton, the vertebral column is the really essential part, all the others being merely appendages of this all-important section. As its presence forms also the essence of the classification of zoologists, anatomists, paleontologists, and of all scientific men, it is absolutely necessary, whatever view the student may have in his studies, that the nature and form of this structure be well understood. It will be described in detail in a future part of the work, more appropriately than here; all that is requisite to say of it in this place, is, that it is composed of a series of bones, articulated in the most admirable manner with each other, and with the appendages, such as ribs, limbs, &c., connected with it. For the sake of description, it has been divided into regions, containing a varying number of distinct bones, or vertebræ; these regions are, the cranial, cervical, dorsal, lumbar, sacral, and coccygeal, which, in the lower animals, are usually called caudal*. A recol-

* Adjectives derived from their respective nouns—as cranial, from cranium, the skull; cervical, from cervix, the neck; dorsal, from dorsum, the back; lumbar, from lumbi, the loins; sacral, from sacrum, the

lection of these facts, and a clear perception of the relation of these regions to each other, will much contribute to the right understanding of the whole animal frame.

CHAPTER II.

OF THE FUNCTIONS AND INTIMATE STRUCTURE OF ANIMALS GENERALLY, AND OF MAN ESPECIALLY.

When an animal body is looked at entire—that is, clothed with all its soft parts—to the uninitiated, if I may so say, it constitutes a piece of machinery so complex, that to unravel it seems a work above the human faculties; yet we find that it is not so, but that, in the course of ages, men of genius and industry have succeeded, by means of anatomical research and by experimental physiology, to acquire a very clear idea of the structure, and such a knowledge of the functions of the organs composing the animal body, as to entitle the knowledge so acquired to the name of a Science. Various means or methods have been adopted, at various times, to obtain this knowledge. A simple analysis of the organs by dissection, from without inwards, might be at first supposed the easiest, as it seems to be the readiest way of acquiring, not merely a knowledge of the topography of all the organs, but also of their intimate structure, and even of their functions;

name given to certain vertebræ when united, so as to form, as it were, but one bone; coccygeal, from coccyx, the name given, in man, to the four last bones of the column; in the lower animals, these vertebræ are called caudal, from cauda, a tail.

but the most ample experience has shown that, by such an analysis, a very imperfect knowledge can alone be acquired of a structure so complex as that of Man, or of any other animal. The zoologist proceeds, then, by a method having more of a synthetical character. As an anatomist, he examines the structure by systems of organs, such as the osteological, myological, neurological,* &c.; as a physiologist, he considers, first, the nature of the functions and their co-relations and dependence on each other. Preparatory to this, or subsequently, as he may see fit, he examines into the intimate nature of the textures out of which all animal bodies are formed, and this analysis is either *simple* or *microscopic*. I shall now examine these textures in the order just mentioned.

In the composition of the organs forming Man, we find the following tissues, which may be easily examined without the aid of any powerful microscope, a common lens being all that is required, and a good sight may generally dispense even with this aid.

PRIMARY.

I.—1. The connective or cellular tissue.
2. The muscular fibre.
3. The nervous tissue or fibre.

SECONDARY.

II.—1. The osseous.
2. The vascular.

* Osteological, from *os*, a bone; myological, from *mus* (Gr.) a muscle; neurological, from *neuron*, a nerve, &c.

3. The cartilaginous.
4. The fibro-cartilaginous.
5. The glandular.
6. The ligamentous.
7. The serous.
8. The synovial.*
9. The dermoid.†
10. Mucous.

When these tissues are examined under the powerful microscopes of modern times, they are found to be resolvable into simpler elements, of which the primitive cell and its nucleus, discovered by Schwaan, form the basis. The elements revealed by the microscope are called *histological;* they play a conspicuous part in modern physiology and pathology, and their investigation promises to lead to important results.

Analysis by Functions.

The best analysis of an animal body is drawn from a consideration of the functions it performs. This may be called the physiological analysis. Now, physiologically speaking, every animal is formed for the exercise of its senses; so a consideration of this fact led the illustrious Bichat to divide the animal functions into—1st. Those of relation to the external world; 2nd. Those of preservation of its own structure; 3rd. Those of reproduction. To the first of these he gave the name of animal functions;

* Synovial, from synovia, the joint-oil.

† Dermoid, the integumentary, from dermis, the true skin.

to the second that of vegetative, or organic. These names are open to many objections, no doubt, but none so good have ever yet been offered.

I.—FUNCTIONS OF ANIMAL LIFE.

That which, in an especial manner, characterizes an animal, is the evidence it offers of its power to perceive the presence of an external world. Now, this power it possesses by means of the organs of sense (*instrumenta sensuum*), which in Man, and in most of the higher animals, are five in number, namely:

Function.	Instrument or Organ.
1. Sense of touch. . . .	The skin.
2. ,, taste. . . .	The tongue.
3. ,, smell. . . .	The nose.
4. ,, hearing. . . .	The ears.
5. ,, seeing. . . .	The eyes.

These are the instruments by means of which Man acquires a knowledge of the external world. The sensations derived through these are transmitted by means of nervous cords to the brain, where they become perceptions, and they necessitate a series of functions and organs for their performance, which may be thus enumerated:

Functions.	Organs.
Perception, Reflection, Volition, and Reaction by motion.	Nerves of Sensation, Brain and spinal marrow, Nerves of motion.

To react on the external world, to enable the animal to pursue what is useful or agreeable to it, and to avoid what is hurtful, organs of locomotion have been provided. These are:

Functions.	Organs.
1. Passive organs of locomotion . .	The bones, ligaments, and articulations.
2. Active organs of locomotion. . .	The muscular system, usually called voluntary.

II.—The organs just enumerated constitute all that is absolutely required for the life of relation, and characterize, in an especial manner, animal life. But the machine thus formed requires support. Reactions constituting life tend to wear out and to destroy the organism. These actions never cease, and they must be met by restorative means, equally energetic and unceasing. This is effected by the process termed *nutrition*, a complex function, requiring many functions and many organs for its due performance. To the *ensemble* of these, physiologists have given the name of *vegetative* life.

All nourishment is derived from the food. Out of this the *chyle* is formed, and out of that, the *blood;* all the tissues and organs are presumed to be formed out of the blood. To accomplish this great end, without which the animal life of the Globe would soon perish, to every animal—of the highest order, at least—the following functions and organs have been given:

Functions.	Organs.
1. Functions of mastication. . .	The teeth.
2. „ insalivation. . .	Salivary glands.
3. „ deglutition. . .	Gullet, pharynx.
4. „ digestion by the stomach, or stomachal. . .	Stomach.
5. „ digestion by the intestines; intestinal. . .	Small intestines.
6. „ defœcation, or excretion.	Large intestines.
7. „ secretion; hepatic, pancreatic, mucous . . .	Liver; pancreas, mucous glands.

All these organs have more or less to do with the formation of the chyle.

The chyle thus formed requires to be absorbed or taken up by vessels, and conveyed by similar means to all parts of the body, there to be deposited, and converted into those tissues and histological or microscopic elements of which I have already spoken, and out of which all the organs are formed. The functions which this process necessitates, and the organs by which these functions are performed, may be thus enumerated:

Functions.	Organs.
1. Absorption of the chyle. . . .	Lacteals.
2. Absorption of the lymph. . .	General absorbents.
3. Conveyance of these to the venous system.	Thoracic duct.

Functions.	Organs.
4. Circulation of the venous blood mixed with the chyle. . .	Veins.
5. Organ of propulsion of the venous blood, mixed with the chyle.	Heart; right side.
6. Conversion of the venous blood, mixed with the chyle, into arterial blood, or respiration.	The lungs.
7. Circulation of the arterial blood formed in the lungs through the body.	Pulmonary veins; left side of the heart; arteries.

Between the termination of the arteries and the commencement of the veins is placed a system of vessels called capillaries, in which, or connected with which, it is generally admitted that the function of the nutrition of the organs is performed.

But, in addition to the functions thus enumerated, and the organs by which these functions are performed, anatomy and physiology teach us, that the blood requires a further purification, by means of the secreting organs called the kidneys, and that, in addition to the great system of the brain and spinal marrow, usually called the cerebro-spinal axis, and of the nerves of sensation and of motion, which proceed to or from it, there exists another system of nerves and ganglions—the sympathetic—whose functions have not, as yet, been satisfactorily determined.

This system will be described in a future part of the work.

III.—Superadded to these are,

1. The organs of voice.
2. The organs of reproduction,

on which depend the perpetuation of the species.

The object of this Work is to describe the structure and functions of the adult as an individual; the structure of the embryo, on which is chiefly based philosophical or transcendental anatomy, will be merely glanced at. All anatomical and physiological pursuits will be found to be easy to those who have mastered the facts of the structure of the adult individual.

CHAPTER III.

OF THE ORGANS OF THE SENSES: OF TOUCH, TASTE, SMELL, HEARING, SEEING.

I.—Of the Organ of Touch.

The sense of touch resides in the skin, but the perception of the impression is a function, of course, of the brain itself. We may be said to feel by every part of the external surface, and to perceive the presence of external objects, but tact, or touch, properly so-called, resides in,

or depends on, the organization of the extremities of the fingers. The human hand is admirably organized for touch. I shall here consider only that portion of the instrument called the skin.

Instrument of Touch; its Anatomy (Pl. 8, Fig. 10).—The skin is composed of two principal parts: 1. The epidermis; 2. The corium, dermis, or true skin.

1. The epidermis, also called scarf-skin, belongs to the class of epithelial structures; it is insensible, and non-vascular. It varies exceedingly in thickness and in density, and the differences, as they also exist in the fœtus, cannot be the result of external causes.

The scarf-skin is composed of flattened cells, agglutinated together in layers. These arise in what microscopic observers call a blastema, or matrix, formed upon the surface of the true skin. Many of these cells contain pigment, or colouring matter. The blackness of the negro's skin depends entirely on the colour of the structure I now describe; but it is in the cells of the deep layers that most pigment is to be found. These deeper layers were first carefully observed by a celebrated Italian physiologist (Malpighi), and were by him called the *rete mucosum*.*

The cuticle is moulded on the external surface of the true skin; when separated from it by maceration, in the dead body, fine tubular threads may be observed passing between them; they come from the perspiratory glands. The cuticle is mostly composed of *keratin*, a horny substance, soluble in alkalies, but insoluble in water and in alcohol.

* Rete mucosum, mucous net-work.

The true skin is a dense, firm membrane, placed between the cuticle and the subcutaneous cellular tissue. It is a fibro-vascular layer, varying in thickness in different parts of the body; the fibres are interlaced, and blood-vessels and nerves abound, especially in young persons. Internally, the true skin passes insensibly into the cellular tissue, by which it is attached more or less firmly to the subjacent structures. On the free surface of the true skin we meet with the papillæ, which are best seen on the inner or palmar side of the fingers. These papillæ abound with vessels and nerves. By boiling, the dermis is reduced to gelatine, and with tannin it forms leather.

Sense of Touch; Physiology of the Instrument of Touch.—German physiologists have proposed a distinction between the terms, *sensitive* and *sensuous:* tactile impressions are said to be effected by *sensitive* nerves; the operations of the higher senses, by *sensuous* nerves. The whole surface of the skin is more or less capable of distinct tactile sensations; but it is not equally endowed throughout: the hands, or rather, the fingers, constitute the essential organ of touch as an instrument of sense.

The organ, or organs of touch enable us to perceive actions of two kinds: alterations of the mechanical state, and changes of temperature. Violent impressions of either kind give rise to pain; and hence some ingenious men—amongst others, Mr. Alexander Walker—imagined the possible existence of a system of nerves whose function it was to excite pleasurable or painful emotions, as the case might be.

The nerves which run in the corium, or true skin, effect

the tactile sensations, through the intervention of the tissues of the true skin and cuticle, on which the result of the impression essentially depends. By habit, the tactile sensibility may be increased to an extraordinary degree. A person may dip his hand, for an instant, into a mass of molten metal without injury; and hence it is not improbable that the epidermis, besides being insensible and always moist, is also surrounded by a vapour. Two corresponding parts of the skin never furnish a single impression.

II.—Organ of Taste; its Anatomy (Pl. 8, Fig. 11).

The tongue is a muscular and extremely mobile organ, and although not the exclusive organ of taste, may be practically considered as such. It is composed of muscles, which have been divided into the intrinsic and the extrinsic. It assists powerfully in mastication, deglutition, and articulation. The base is behind, and is fixed; the apex is forward, and is free. A mucous membrane, connected with an epithelium (another name for a cuticular covering), covers all the dorsum, sides, and apex of the tongue; on this surface may be seen the nervous papillæ, connected, no doubt, more especially with the sense of taste.

First, of the papillæ: these are of three kinds:

1. The large, arranged in the form of the letter V; these are seen towards the base of the tongue.

2. The middle-sized papillæ, small rounded eminences, scattered over the middle and fore-part of the dorsum of the tongue.

3. The smallest papillæ are conical, and filiform. They are the most numerous of all.

All these papillæ, belonging to the mucous membrane, but covered by the epithelium, are highly vascular and sensitive; nerves proceed in abundance to them, and the nerve tubes enter them.

A vertical layer of yellow elastic tissue divides the tongue, mesially* and longitudinally, into two parts; this is well seen by making a transverse section of the tongue about the middle. This elastic vertical layer is connected with the lingual† bones, and with a fibrous structure, also connecting the base of the tongue to the body (mesial bone) of these lingual bones.

The muscles are numerous and powerful. The *intrinsic* are divided into two principal longitudinal layers, and a large mass of transverse fibres. There are many fibres which seem to be arranged *vertically,* but some distinguished anatomists view these merely as the continuation of an extrinsic muscle called the genio-glossal.‡

* Mesially; a word in frequent use with descriptive anatomists, who divide the whole body into two halves by an ideal line and plane passing through the trunk. To this line and plane they refer their topographical descriptions of the organs. Thus, for example, the eyes are situated mesially as regards the temples. I have seen a person perspire copiously by only one half of the body, the other remaining dry; the perspiration was limited rigorously by the *mesial* line just alluded to.

† *Lingual,* or tongue bones, from lingua, the tongue; hence, linguistic, &c.

‡ Genio-glossal: a muscle attached by its extremities, to the genioid (from geneion, the chin), processes of the lower jaw and the tongue. The terms *glossal* and *lingual* are synonymous.

Of the extrinsic muscles, I give here merely the enumeration;* by their means the tongue can be moved in almost every direction.

The nerves supplying the tongue are derived from three sources.

1st. The lingual branch of the fifth pair, called gustatory; it supplies the papillæ and mucous membrane of the fore-part and apex of the tongue.

2nd. The lingual branch of the glosso-pharyngeal nerve, a division of the eighth pair; this supplies the mucous membrane of the base and the larger papillæ.

3rd. The lingual, hypo-glossal, or ninth pair of cranial nerves of sense, the twelfth pair of others. It is the motor nerve of the tongue, and supplies the muscles. All these nerves proceed to the tongue in pairs—that is, one on either side. The tongue, moreover, is extremely vascular.

Organ of Taste; Physiology.

A liquid state is the necessary condition of taste. Hence, insoluble substances cause only tactile sensations, but they give rise to no true gustative impressions.

The tongue is usually regarded as the exclusive organ of taste, but it is not so, nor is every part of it sensible of the presence of sapid bodies. The upper and anterior half of the extended tongue is not sensible to the taste of a piece of salt, or a drop of vinegar, or a solution of the

* Genio-glossal; hyo-glossal; stylo-glossal: muscles connected with the chin, hyoid or lingual bones, styloid process of the temporal bone and the tongue.

extract of aloes, and these are only perceived as sapid bodies when they extend to the inferior surface, or root; when there, the smallest quantity of any sapid substance is distinctly perceived. This is, perhaps, due to the fact, that the nerves of taste are distributed to the root of the tongue, its anterior half being chiefly supplied by nerves of touch.

The papillæ, obviously connected with the gustatory sensations of the tongue, have been already alluded to.

It would seem that sweet and bitter substances can be tasted at other places besides the root of the tongue. Nevertheless, the lips, the inner surface of the cheeks, the gums, the skin of the hard-palate, and the greater part of the upper surface of the anterior half of the tongue, are always devoid of the sense of taste. The root of the tongue occupies the first gustative rank; the fauces* are capable also of taste, though less rapid and delicate.

A view of the distribution of the nerves to the tongue will be found in Fig. 11, Pl. 8, of the Atlas. Of these nerves, the glosso-pharyngeal† (lingual branches) seem the most acutely sensible to taste.

The organ is liable, also, to false sensations, which the Germans call *subjective,* as originating in the brain, and not in the perception of any body applied to the tongue; but the theory is open to objections, and the phenomenon may be explained otherwise.

* Fauces: the narrow part of the throat between the cavity of the mouth and the cavity of the pharynx—that cavity, namely, which surmounts the gullet.

† Glosso-pharyngeal: a nerve proceeding to the tongue and to the pharynx.

III.—Organ of Smell; Anatomy.

The organ of smell is considered as taking a higher rank, physiologically, than that of taste; its seat is high in the nostrils, and a special pair of nerves, the first, or olfactory, is devoted to it.

The nose, besides being the special organ of the sense of smell, performs other functions. It forms the commencement of the respiratory tube, and hence is connected with respiration and with the voice.

The organ consists—1. Of the anterior prominent part, composed of bone, cartilages, muscles, and integuments. These need not be particularly described. Nevertheless, this part of the organ is remarkably characteristic of the various races of men; so also are the nasal bones, which support its upper portion, and the cartilages, which constitute the framework of its lower part.

2. Of two orifices, the anterior nares, or nostrils, leading into 3. the nasal fossæ; 4. two apertures, called the posterior nares, or nostrils; 5. an extensive mucous membrane, called pituitary,* investing all the inner surfaces of the nose, and even penetrating into certain cavities called sinuses;† 6. a pair of nerves, the olfactory, especially devoted to the organ; 7. branches of the fifth pair, the presence and integrity of which seem essential to the due

* Pituitary membrane: the membrane lining the interior of the nostrils. The ancients gave the name of pituita to the mucous discharge from this membrane. It was also called Schneiderian, from the name of a German anatomist who described it with great care.

† The frontal, ethmoidal, sphenoidal, and maxillary sinuses.

performance of the functions of the organ (see Fig. 12, Pl. 8; also Fig. 2, Pl. 7); 8. a septum, or partition, dividing the nostrils into two great cavities; this is partly osseous, partly cartilaginous, and is invested throughout by the same mucous membrane, called pituitary (see especially Fig. 12, Pl. 8).

As regards the pituitary membrane, the microscope shows that it is protected by a layer of epithelium, which, anteriorly, is laminated; it contains, likewise, a layer of mucous glands, and where it invests the sinuses it shows, under the microscope, vibratile cilia.*

The blood-vessels of the nose do not require any special description. They are numerous. The nerves also are numerous. Of these, the most important is the olfactory, or first pair (Figs. 1 and 7, Pl. 7). The ultimate distribution of this pair of nerves is to the pituitary membrane, where it invests the septum and the superior and middle turbinated† bones. These bones are merely processes of the ethmoid bone, through the cribriform‡ plate of which both nerves make their way into the nose. The more remarkable of the other nerves which supply the nose, is a branch from the ophthalmic division of the fifth pair.

Organ of Smell; Physiology.

We learn from daily experience that very small quanti-

* The cilia spoken of here are fine, thread-like bodies, microscopic, and vibratile, revealed by the microscope on the surfaces of many of the membranes of animal bodies.

† Turbinated: rolled up like the whorl of a univalve shell; turbo.

‡ Cribriform: full of holes like a sieve.

ties of many odorous substances suffice to excite the sense of smell. Amongst these may be mentioned musk, tobacco, ambergris, phosphuretted hydrogen, &c. One or two millionth part of sulphuretted hydrogen will excite or act on the olfactory function. But the sense of vision is quite as acute, for a glass rod moistened with hydrochloric acid forms a white vapour, even when its quantity is too minute to be perceived by the human olfactory sense. Of musk, 1-13,000,000th of a grain can be traced by its smell.

The uses of the several supplementary cavities connected with the nasal fossæ, such as the frontal, ethmoidal sinuses, and others, are unknown. No fibres of the olfactory nerves can be traced to them. In many animals, this organ of sense is of the highest importance to their preservation. It is said to be subject, in Man, to frequent delusions, but I have not observed this to be the case.

IV.—Organ of Hearing; Anatomy.—The Ear.

The organ of hearing is, on each side, composed of three sets of organs, to which the names of—1. external ear; 2. middle ear; 3. deep, or internal ear, have been given. The deep alone forms the essential part of the compound organ.

1. External ear. The skin of this region is remarkably fine and delicate. Its sebaceous follicles are numerous. A cartilage forms the basis of the external ear, but it does not extend into the lobe. This cartilage is continuous with that forming the cartilaginous tube which

passes towards the middle ear, and is connected by a fibrous membrane with the osseous portion of the canal. (See Pl. 6, Fig. 6. *a*. External ear. *b*. The lobe of the ear. *c*. The cartilaginous tube, or passage, leading to the tympanum, or middle ear.—Also Fig. 9, Pl. 6. *a*. The external ear. *c*. The auditory passage, or canal. *d*. The tympanum, or middle ear.)

The auditory canal extends from the concha, or external ear, to the membrane of the tympanum, called, in common language, the drum of the ear. Within this, and deeper, lies the cavity of the tympanum, in which are lodged the small bones of the ear (ossicula auditus); this cavity communicates by a tube—the Eustachian tube—with the pharynx, behind the nostrils, and with the mastoid cells of the temporal bones (Figs. 6, 7, and 8, Pl. 8).

In the cavity of the tympanum are placed the small bones of the ear, ossicula auditus (see Figs. 6, 7, and 8, Pl. 8), called malleus, incus, and stapes,* to which some add an orbicular bone. The first resembles a hammer, the second an anvil, the third a small circle or globe, and the fourth a stirrup. The base of this last bone is inserted into an oval-shape foramen, or opening (fenestra ovalis), by which the osseous tympanum communicates with the osseous vestibule, or middle portion of the deep ear. Other openings lead to or from the tympanum; these are the fenestra rotunda to the cochlea, the opening to the mastoid cells, the extremity or commencement of the Eustachian tube, &c. A mucous membrane lines the interior of the cavity.

* Malleus, incus, stapes: hammer, anvil, stirrup.

2. The deep, or internal ear, is formed of three parts: the vestibule, the cochlea, and the semi-circular canals. Into these penetrate, by the osseous internal meatus,* the auditory nerve, on which the sense of hearing depends. All these parts are well represented in Fig. 6, Pl. 8, a figure which gives a connected view of all the structures.

Organ of Hearing; The Physiology.

We hear by means of waves of sound, which impinge upon the outer ear, and penetrate by the tube to the membrane of the tympanum; but many rays of sound are reflected from the ear, and are lost. Physiologists admit that the peculiar form of the human external ear can scarcely be explained, and that, at present, we do not know the cause of its strange shape, and its numerous elevations and depressions. Over the external ear man has little or no power, very few having the faculty of moving it, even as a whole.

The loss of the external ear merely diminishes the acuteness of perception.

The waves of sound are propagated inwards by the external auditory canal. It is in this canal that the wax of the ear is secreted by peculiar glands.

The tympanum, or membranous partition which separates the external meatus from the cavity of the tympanum, by its connection with the small bones of the ear, which are acted on by appropriate muscles, admits of tension and relaxation.

* Meatus: a passage.

The sonorous vibrations taken up by the tympanic membrane are propagated onwards along the chain of the small bones of the tympanum. Yet, the accidental loss of these bones by disease does not always destroy the sense of hearing.

The uses of the Eustachian tube are not well known, but obstructions in it undoubtedly affect the sense, and require to be removed by injections, or remedied by perforating the membrane of the tympanum.

The deep ear, and especially the labyrinth, is filled with a liquid, which some have called the vitrine of the ear; in it are certain minute particles of carbonate of lime, called *ear-sand,* or *otoconia;* in fishes, they are large, dense substances, and are named otolites. The fluid is called endolymph, and on the membrane enclosing it are spread branches of the auditory nerve. Branches of the same nerve proceed to the interior of the cochlea and semicircular canals.

The exact use of the semi-circular canals is, at present, unknown. The same remark applies to the cochlea. All this arises, in some measure, from the defective state of our knowledge of acoustics.

Auditory perceptions are limited to sounds possessing a certain strength; but there are sounds which are quite inaudible to certain ears, though perceptible to others. Savart concluded, from his experiments, that the lowest note perceptible by the human ear is composed of from 14 to 16 vibrations in the second, and the highest of 64,000. The ear cannot count the number of vibrations. The delicacy with which two approximate but discordant

notes can be distinguished by some, and not by others, is very remarkable; those who have not a musical ear cannot comprehend this, and the mistakes such persons make are occasionally ludicrous.

Relations to space are much less perfectly perceived by the ear than by the eye. Thus, it seems impossible by the ear alone to point out the quarter whence any sound comes. Delusions of this sense are frequent, and may arise either from an alteration in the structure of the organ itself, in which case they bear a relation to objective sensations; or they may be purely subjective—that is, originate in the brain itself. Of this character are, probably, the frequent noises in the ear which attack the aged, but which also, no doubt, occasionally originate in a disordered condition of the organ itself.

In the descending scale of animals, the external and middle ear disappear first; next, some parts of the deep ear, as the cochlea and semi-circular canals; the vestibule, as the essential part, probably always exists.

V.—Vision.—The Eye.

The organ on which the important function of vision depends is the eye-ball. To its anatomy and physiology, numerous researches have been devoted, and mathematicians of the highest order have not thought it beneath them to examine into the structure of this wonderful organ, by means of which the minutest and the grandest objects of creation are made known to man. The "Optics of Newton" would alone have immortalized that wonderful man.

Anatomy of the Organ.—It will be found greatly to assist the reader in comprehending the structure of this most wonderful of the instruments of sense, were he to place before him the eye of the sheep or ox, and, as he reads, make out by dissection, the various structures I am about to describe. There is nothing difficult of comprehension in the anatomy of the eye, if examined systematically and methodically.

The organ is usually subdivided into two sets of parts or structures: 1. The tutamina oculi or protecting parts of the eye-ball. 2. The eye-ball itself.

(Pl. 8. Figs. 4 and 1). The *tutamina oculi** may be thus enumerated. The osseous orbits which will be described with the skeleton. The eyelids, two in number, the upper and the lower, formed of the integuments, a ciliary cartilage in each, a fibrous layer, and inside all, a layer of membrane reflected from off the eye-ball, and called the tunica conjunctiva oculi. In the upper eyelid there is besides, the tendon of the muscle which raises up the upper eyelid; and in both eyelids a layer of the orbicular muscle of the eyelids, which closes the eyelids at will. Besides the two fully developed eyelids, minute anatomy shews the presence of a third or vertical eyelid, placed towards the inner angle of the eye; this is a rudimentary structure which is fully developed only in some of the lower animals, and more especially in birds. By drawing it across the eye-ball, the eagle can gaze at the mid-day sun in all its splendour.

Placed within the orbit and towards its outer angle, but

* Safeguards of the eye.

exterior to the eye-ball, is the lachrymal gland,* (Fig. 4, Pl. 8). On the inner edge of either eyelid may be seen on careful inspection, two small openings, called puncta lachrymalia. These lead to two ducts, and these again terminate in the lachrymal sac, which communicates with the corresponding nostril by what is called the nasal duct. Thus the tears formed by the lachrymal gland are taken up by the puncta lachrymalia, and conveyed to the nose. The whole apparatus is represented in Fig. 4, Pl. 8, where *g* marks the lachrymal gland of the left side; *a* the punctum, on the ridge of the upper eyelid; *c* the nasal duct. In addition to these, the eye-ball is moved by the following muscles: four straight muscles or recti (Fig. 1, Pl. 8), called from their position, internal, external, superior and inferior. Of these, the internal is the one generally at fault in *squinting*, and the section of this muscle has been often performed in Britain for the remedying of this deformity. The other muscles found within the orbit connected with the eye-ball, are the superior oblique and inferior oblique muscles. There is also a small muscle connected with the margins of the eyelids, and attached to the lachrymal bone; it is called the tensor tarsi, *i. e.* tensor of the tarsal cartilages. I shall speak presently of the uses of all these parts. The eye-ball itself is composed of membranes and humors, and is connected to the brain by the optic nerve. The tunics are: 1. the sclerotic, or fibrous, and continuous with it, the cornea; of these, the cornea alone is perfectly transparent. Over its surface is spread the tunica conjunctiva oculi. Just within these tunics will be found—2. the choroid or vascular mem-

* Lachrymal: from lachrymæ, the tears.

brane with its pigment; continuous with this is the iris. The ciliary folds are appendages of the choroid, and the ciliary body or ligament which connects the choroid to the sclerotic, is now admitted to be a muscular organ, resembling in this respect the iris (Fig. 5, Pl. 8).

Within the choroid is placed—3. the retina, or sensitive membrane, usually considered to be an expansion of the optic nerve; and within these the three humors of the eye; the vitreous,* the aqueous, and the chrystalline, or lens (Fig. 3, Pl. 8). All these parts are well displayed in the figures, but it will be well to look at them also in nature.

Physiology of the Organ of Vision.—Sight.

The eye is a globular mass attached to the optic nerve, and imbedded in the fat contained in the cavity of the orbit. From the orbit the nerve passes backwards through the foramen opticum into the interior of the cranium, and so reaches the brain. Whilst within the cranium it decussates with the nerve of the opposite side, at least partially. By means of its six muscles the globe of the eye can be directed towards any object with the greatest facility, and both eyes made to bear on the same object; as very fluent speakers occasionally stutter when embarrassed, so persons whose eyes are usually quite under their control, may occasionally squint. The same explanation applies to both phenomena.

A ray of light passing through the same medium, always takes a rectilineal course, but if it meets with a medium of a different kind or density, four different effects may

* So called from its resemblance to molten glass.

result. Part of the ray is dispersed on all sides, while another part is reflected in a regular or prescribed path. If the new medium be transparent, part will pass onwards in a refracted state. Finally, part is absorbed or lost in the interior, probably by partial reflection and interference. (See Fig. 2, Pl. 8). Now this is what takes place in vision. The rays of light passing from luminous bodies are collected into a focus on the concave surface of the retina behind all the humors, and on which an image of the visible body is depicted. The impression thus made on the nervous retina, is transmitted by the optic nerve to the brain by which it is perceived. Before reaching the retina, the rays of light must first pass through the cornea, the aqueous humor, the pupil or opening in the centre of the iris, the lens and its capsule, and the vitreous humor and its capsule. All these structures are transparent, but possessing very different densities the rays of light are more or less strongly refracted towards the perpendicular by each of them. The adjustment of the eye is now thought to depend on the structure called the annulus albus or ciliary ligament, a portion of which is now admitted to be muscular. This opinion I maintained so early as 1822.*

The defect called short-sightedness or myopia, is due to the point of furthest vision being too near; in long sightedness or presbyopia, it is the nearest point that is too distant. When the lens becomes opaque, the disease is called cataract, and the operation for the cataract consists in removing by surgical means, the opaque lens or the capsule, as the case may be, out of the direct line of vision. The spectacles required to be used after such an operation,

* See Transactions of the Royal Society of Edinburgh.

are the most powerful convex lenses ever called in to aid the abnormal sight.*

In the human eye, (but not confined to it), there is a remarkable yellow spot on the retina in the axis of vision, and beside this, a small irregular hole or foramen in the nervous tunic of the retina itself. This circumstance has given rise to much speculation, and many conjectures, for the hole, in question, is in the axis of vision. As we see all things inverted, erect vision is a phenomenon quite inexplicable as yet. Persons who have been born blind, and afterwards receive their sight, see objects at once in the erect position.

The point of the retina corresponding to the entrance of the optic nerve is insensible to the rays of light. None of our senses is more subject to delusions than the eyes; these are either subjective or objective.

CHAPTER IV.

OF THE ORGANS OF PERCEPTION, REASON, VOLITION.—INNERVATION.

The organs of the senses transmit to the brain, through the nerves connected with them, the impressions made on them by the external world; on reaching the brain they are perceived by it, and become perceptions and ideas. In this form they are reasoned over, and action follows. Thus the brain and spinal marrow, (for they cannot be separated in this view) form the central organs towards which all

* Abnormal: that which is not *normal*, or regular; against the law.

sentient nerves proceed, and from which all nerves which are to regulate the muscular actions obeying the will also emanate. The muscular or locomotive system of organs to which these latter nerves proceed, are formed expressly for and in strict unison with these motor nerves. To render these muscles of use, levers are provided; these are the bones constituting the skeleton, and the necessity for these being connected together, and enabled to move or slide freely over each other, gives rise to the apparatus of ligaments, synovial capsules, cartilages of incrustation, &c.

The organs already described, with those I have just enumerated, constitute the organs of animal life; the life of relation.

I. Central Organs of the Cerebro-spinal System.—Brain and Spinal Marrow. (See Pl. 7, Figs. 1, 2, 7).

Anatomy.—The brain and spinal marrow are enclosed by three membranes; these are, 1. the dura mater or fibrous, and protecting membrane. 2. the arachnoid or serous. 3. the pia mater or vascular. This latter immediately invests both organs, sending numerous blood vessels into their substance. On these being removed, we have next the proper nervous substance of both organs. Turn to Pl. 7, Fig. 1, for a view of the brain and spinal marrow, together with the roots of the nerves as first seen, when removed from the osseous case containing them, and stripped of their tunics or membranes. The surface exposed here is the inferior or ventral aspect, and the parts seen, from before backwards are: 1. the anterior lobes

of the brain. 2. the middle lobes. 3. the cerebellum, or little brain, which in this view conceals the greater part of the posterior lobes of the brain placed above it. The cranial nerves may be readily traced by their numbers, whilst the spinal nerves and the plexuses they form, require no further explanation than has been already given in the atlas.

Fig. 7, contains a vertical section of the brain, carried downwards through its inter-hemispherical fissure; the parts seen are the corpus callosum, the interior of the ventricles, and the exterior of the cerebellum; the figure also gives a good view of the distribution of the fifth pair of nerves. Fig. 2, of the same plate gives also a view of the vertical section of the brain, not materially differing from the preceding.

The male adult brain has an average weight of 49½ ounces; the female of 44 ounces. The maximum has been stated for the male at 65 ounces; for the female 56 ounces; the minimum for the former at 34; for the latter at 31 ounces. The male brain differs in its form from the female, the latter being narrower in front. The brain of the illustrious Cuvier weighed 64 ounces; that of Dr. Abercrombie, 63. Originality or genius does not seem to be necessarily connected with bulk of brain.

The vascular membrane called pia mater, is not confined to the exterior of the brain, but penetrates into the interior by a wide fissure which was known even to Galen, and was redescribed by Vesalius. It enters the ventricles of the brain forming plexuses of blood-vessels. These ventricles are five in number. When watery effusions collect

therein, the disease is called hydrocephalus internus; water in the brain.

I. Cerebro-spinal Axis, or Central Organs of the Nervous System.

Physiology.—The term innervation has been invented to express all the functions which may be ascribed to the agency of the nervous matter. In this section I shall consider chiefly the functions of the brain, spinal marrow, and nerves, as these latter have relation to the functions of locomotion and the voice; reminding the reader, however, that although the functions I am now about to speak of, constitute the more striking, and characteristic functions of these organs and structures, they do not embrace all. By means of the sympathetic system of nerves, to be described at the close of this great section, the brain or spinal marrow unquestionably influence all the organs of nutrition, and thus by connecting the animal and the organic functions by close relations, they form of the whole an individual.

In one sense it seems easy to determine the general functions of the brain and nerves, which are in direct connexion with it. The sensations we receive through the organs of sense are conveyed by the nerves of sensation to the brain and spinal marrow; there they become perceptions, and are subjected to the reasoning powers. From the brain flow the dictates of the will, and man's reaction on the external world; to enable him to act thereon with advantage, bones, ligaments, and muscles are pro-

vided, over which, in health, he has the most absolute power.

The apparatus I am now about to describe, together with the instruments of sense already treated of, constitute *the animal* properly so called. But when we endeavour to localize the functions, and to ascribe to each part its due share in the result, we encounter difficulties as yet insurmountable.

The nervous system is divisible into two chief portions, a centre and a periphery. The centre is composed of the brain and spinal marrow; the periphery of the nerves. But this latter may be subdivided further into two portions, namely, cerebro-spinal nerves and sympathetic nerves; the former in direct communication with the brain and spinal marrow; the latter indirectly connected with these. Moreover, in the peripheral portion we find two kinds of organs, namely, knots or ganglions, and cords or nerves; the nerves are composed of primitive nerve-fibres; the ganglions have besides these fibres, a peculiar structure called ganglion-globules or corpuscles. Every nerve fibre has a sheath called *neurilema.*

Although the nerves anastomose or communicate freely with each other, the primitive fibres are never lost, and thus the mode in which these terminate has never been discovered. Now, if every nerve-fibre remained isolated throughout its whole course, the number of primitive fibres in the total peripheric system would not exceed that contained in the roots of the cerebral and spinal nerves; but physiologists now generally admit that many of these primitive fibres subdivide in their course into others still

finer. These finer branches run in the interior of organs, and form plexuses. The more generally received opinion is that the nerves terminate in the organs by *loops*.

It has been known since the time of Galen, and is, indeed obvious from the commonest observation, that there must be nerves of pure sensation, and others whose function is solely to excite motion by means of the muscles. Thus the distinction of nerves of motion, and nerves of sensation has existed for many centuries, requiring for its determination merely the commonest observation. But this was far from rightly determining the many questions connected with the nerves. Accordingly it was suggested by Dr. Johnston of Salisbury, about a century ago, that nerves on which ganglions are placed, must be merely nerves of sensation, whilst those on which there were no ganglions are nerves of motion. This doctrine taken up by Walker, Bell, and others, and applied to the spinal nerves, turned out to be nearly the correct one, and experiment seemed to shew that the anterior roots of the spinal nerves, on which there are no ganglions, are nerves of motion, and the posterior roots which have ganglions are nerves of sensation.

These experiments and observations are far, however, from determining, as we shall presently find, the many difficult questions connected with the physiology of the nerves. Thus many physiologists consider the so called olfactory and optic nerves as merely prolongations of the brain itself. On the other hand, all the spinal nerves, and most of the cerebral or cranial nerves are double nerves, that is, they contain sensitive and motor filaments,

wrapt up together in their course, seemingly quite distinct at first. This has been demonstrated by numerous experiments. (See Fig. 8, Pl. 7). But it has been proved* that the anterior roots have a *recurrent* sensibility which they owe, no doubt, to the posterior roots.

On irritating a part of the skin (with or without consciousness, as the case may be), certain corresponding muscles may contract, wholly independent of the will: the contractions produced in this indirect way are called "reflex movements."

The only true cerebral nerves are: the olfactory and a portion of the optic; all the others which pass through the cranium do not proceed from the brain itself, but from its means of connection with the spinal cord and brain, that is from the medulla oblongata. These cranial nerves may be thus enumerated: 1. The olfactory or nerves of smell. 2. The optic, nerves of sight. 3. The motor oculi, or the nerve which supplies most of the muscles moving the eyeball. 4. The pathetic nerve, or nerve of motion supplying the superior oblique muscle. 5. The trigeminate nerve; a compound or double nerve; the nerve of sensation of the face, and by its motor root supplying the muscles of mastication. 6. The nerve to the external straight muscle of the eye ball. 7. The facial nerve, and the auditory: the first portion supplying most of the muscles of the face; the second portion being the nerve of hearing. 8th pair, composed of three portions: *a.* The glosso-pharyngeal, supplying parts of the tongue and pharynx, with sensitive and motor nerves. *b.* The

* Brown-Sequard.

pneumo-gastric,* proceeding to the larynx, lungs, gullet, and stomach. *c.* The spinal nerves (accessory), supplying certain muscles of the neck. 9th pair, or motor nerves of the tongue, also called hypo-glossal.

The spinal nerves are all double nerves, *i. e.* motor and sentient. Besides sending branches innumerable to the muscles and the integuments, they communicate by branches with the sympathetic system of nerves, a system I shall now briefly describe.

The sympathetic system of nerves is represented by a series of ganglions on either side, arranged along the front and sides of the vertebral column from the atlas,† to the terminating coccygeal bone. These ganglia are all united to each other by communicating filaments, so that they form an uninterrupted series; from these ganglia proceed filaments connecting them with the cerebro-spinal nerves, and many others which proceed to the organs of organic life, which they chiefly supply. It has been supposed, also, that they send numerous filaments along the tunics of the arteries and veins. The precise functions of this system of nerves have never been fully determined, but it would seem that they are in some way or other intimately connected with the nutrition of the body, the secretions, excretions, &c.

In a healthy condition, the organs supplied by the sym-

* Pneumo-gastric nerves: nerves supplying the lungs and stomach; gastric, from *gaster*, the stomach, a Greek term, and the root of many others. Pneumo from *Pneumones* (Gr.) the lungs.

† Atlas: the first cervical vertebra, so called from its supporting the head.

pathetic are insensible to the stimuli which most excite the other nerves; but when diseased, these organs become not infrequently acutely sensible to painful impressions. In connection with the action of the nerves over the muscular fibres, it may be observed that the cause of the rythmic action of the heart remains as yet wholly unexplained.*

The great physiological question here is, the independance of the sympathetic system of nerves; this question has not as yet been solved.

The lungs derive their nerves from the eighth pair, and from the sympathetic also; so does the stomach. The influences which the nervous system is capable of exercising on the local phenomena of circulation, secretion, and nutrition, are very imperfectly understood.

The nervous principle, or agent, strongly resembles electricity in its phenomena; but there exist differences implying, as it were, a distinctness of character, and experimentors on these difficult and delicate questions, have come to the conclusion that the function of the nerves essentially depends on the molecular state of the nervous substance, and that this is greatly altered at the instant of their action. Hence the nervous principle works by means of material changes; and the nervous medulla possesses a mobility, in this respect, such as has hitherto been found in no other substance.

The electricity produced by the so called electric fishes, resembles common electricity in all its properties. This fact ought never to be lost sight of by physiologists.

* The heart receives its supply of nerves chiefly from the sympathetic system; a few branches of the eighth pair of cranial nerves also proceed to it.

II.—Functions of the Brain and Spinal Marrow.—The Brain. (See Pl. 7, Figs. 1, 2, and 7).

As the brain is the most important organ in the body, it might be supposed that its physiological history would occupy a space corresponding to its importance. But this we shall find is not the case, and for this sufficient reason, that but little is known of the functions of the brain, beyond the plainest facts and observations manifest to all capacities. On this point, even, its minute anatomy is not understood.

First, as regards the spinal marrow, we know that it does not represent a single nerve, but that it, perhaps, is composed of a series of ganglions united to each other by transverse and longitudinal commissures of a thickness equalling that of the ganglions themselves. When the spinal marrow is cut across, or effectually destroyed, all sensation and power of motion is lost in the parts below, or beyond the section.

It has been known, ever since physiology was studied, that certain motions, or corporeal acts, follow certain sensations, independent of our will, and even of our consciousness. To this great group of functions it has been fashionable, of late, to give the name of *reflex movements*: such are the closure of the eyelids, when a particle of dust has fallen into the sac of the conjunctiva; sneezing; the involuntary movements of deglutition; cough; the scream sometimes uttered on being suddenly hurt or threatened, &c.

The brain and its membranes completely fill up the cranial cavity. When the brain has been exposed in a living animal, whether intentionally or accidentally, two kinds of movement are exhibited; one coincides with the pulse; the other, with the breathing. Injury done to some parts of the brain causes intense pain; others may be torn, or lacerated, or removed, and the animal remain unconscious of the injury sustained.

Experiments have determined some of the actions of particular parts of the brain, medulla oblongata, and spinal marrow; but they throw little or no light on the phenomena of the higher functions of the brain.

A severe blow on the right side of the head produces paralysis of the left side of the body, proving the decussation of the fibres of the central organs. The greater portion of one of the hemispheres of the brain may be destroyed by disease, and the intellect remain unaltered; at other times, a very slight disease within the head will give rise to a train of the most serious symptoms, such as weakness of intellect, imbecility, lethargy, &c. A limpid fluid, called the subarachnoid fluid,* fills up all the vacant spaces within the cranium and spinal canal, and its presence seems essential to the right performance of the functions of the contained organs.

So slight are the foundations which physiology and anatomy furnish to psychology, that no rational theory of mind can as yet be attempted. The phrenological systems

* Subarachnoid: that which is placed beneath the arachnoid membrane of the brain and spinal marrow.

hitherto offered are held by rigid physiologists to be devoid of all truth.

CHAPTER V.

ORGANS OF LOCOMOTION: 1. PASSIVE. 2. ACTIVE.—A. BONES; B. ARTICULATIONS; C. MUSCLES AND TENDONS. (SEE PLS. 9, 10, 11, ALSO FIG. 2, PL. 7, AND FIG. 1, PL. 6, FIG. 1, PL. 5).

A. The Bones.

Anatomy.—The skeleton is that aggregate of bones forming the frame work of the animal, determining its general proportions, giving attachment to the muscles and forming the levers on which they act, and by which the body is transported from one place to another. The essential feature of the human skeleton as, indeed, of all vertebrate animals, is the presence of a series of bones called vertebræ, which modern philosophical anatomists, since the great discoveries of Goethe and the transcendental anatomists Oken, Spix, and Geoffroy St. Hilaire, have agreed to arrange as follows:

IN MAN:

Cranial vertebræ		3 or more, not yet determined.		
Cervical	"	7	"	"
Dorsal	"	12	"	"
Lumbar	"	5	"	"
Sacral	"	5	"	"
Coccygeal	"	4	"	"

These constitute the vertebral column. The cranial vertebræ constitute the skeleton of the head (cranium and face), and its bones are intimately united to each other, so as not to admit of motion, with the exception of the lower jaw. The other vertebræ are strongly united to each other by ligaments, of which some (the intervertebral substances) are highly elastic. But anatomists generally give the name of vertebral column, properly so called, to the portion commencing with the atlas, or first cervical vertebra, and terminating with the last coccygeal.

This portion of the column, however it may be viewed, is in general highly elastic and flexible. To the dorsal portion are attached, also by ligaments, 12 ribs on each side, making 24 in all. Of these, the 7 uppermost are extended to the sternum, or breast-bone by cartilages, called costal; the lowermost 5 have cartilages of prolongation also, but they do not extend to the sternum. These 5 ribs on either side are called false ribs; the upper 7 are the true ribs.

Articulated with the three uppermost sacral vertebræ, are the broad bones of the pelvis, called nameless bones, or ossa innominata. These, in young persons, are formed of three distinct bones, called ischium, ilium, and pubis; but as the person becomes adult, these three coalesce into one. The vertebral column is wedged into the pelvis, or basin. This, therefore, forms a kind of basis of support, upon which the trunk can rest upright in the sitting attitude. But when a man stands upright, the legs—which sustain the pelvis, and hence the trunk also—form two columns, in the interval of which the line of gravity descends.

The thorax, or chest, formed of the ribs, their cartilages, and the sternum, or breast-bone, is suspended in front of the vertebral column. It contains the heart and lungs.

The arms of the skeleton are composed of the bones of the shoulder, 2; (scapula and clavicle); the arm-bone, or humerus, 1; the bones of the fore-arm, or radius and ulna, 2. The hand is formed of the bones of the carpus, the scaphoid, semi-lunar, multangular, and pisiform; these form the first row: the second row is formed of the trapezium, trapezoides, magnum, and unciform; the bones of the metacarpus, five in number; the digital bones, or phalangeal, three for each finger, excepting the thumb, which has but two.*

The skeleton of the lower extremity is formed of— 1. the femur, or thigh-bone; 2, the bones of the leg—viz., the tibia and fibula; 3. the bones of the foot—viz., seven tarsal bones, called astragalus, os calcis, or heel-bone, cuboid, three cuneiform bones, and scaphoid; next, the metatarsal bones, five in number; and lastly, the digital phalanges, of the same number as the bones of the fingers.

The ribs and limbs, and even the sternum, are considered by some as appendages of the vertebræ; and in this light also are viewed the hyoid bones, or bones of the tongue (Pl. 4, Fig. 6). But these latter, together with the sternum, or breast-bone, and the os pubis, have been

* Scaphoid, or boat-shaped; semi-lunar, or half-moon; multangular, many-angled; pisiform, pea-shaped; trapezium and trapezoides, so named from the mathematical figures they represent; os magnum, the large bone of the carpus; os unciforme, the hook-like bone.

viewed by some anatomists as independent parts, representing on the front of the body what the vertebræ do on the dorsal part. Thus, the bones composing the sternum have been called sternebræ.

The skeleton of the head is composed of the following bones: 1. the frontal bone; 2 and 3. the two parietal bones; 4. the occipital bone; 5. the sphenoid bone; 6. the ethmoid; 7 and 8. the temporal bones. These form the cranium, properly so-called. In the face, we find the following bones: in the upper jaw—1 and 2. the superior maxillary bones; 3 and 4. the palatal bones; 5 and 6. the malar; 7 and 8. the lachrymal; 9 and 10. the inferior turbinated bones; 11. the vomer; 12. the lower jaw bone.

When these bones are in their place, they form various cavities, as the cranial, the orbits, the buccal, &c.; and between the two tables of which the bones of the cranium are formed, there are, in some bones, sinuses, or cavities, the use of which is altogether unknown. These are the frontal, sphenoidal, and ethmoidal sinuses. The upper jaw bones are also hollowed out into a large cavity on either side, called the antrum of Highmore, or superior maxillary sinus.

Physiology.—Little need be said here of the physiology of this system of organs. Mobility, adapted to the wants of the animal, is, no doubt, one reason for the number of bones we find in certain portions of the skeleton. Other parts, again, are fixed and immoveable.

B. The Articulations.—Their Anatomy and Physiology.

The object of these is to render the bones really useful in locomotion, which without them could not take place. They are either moveable or immoveable; the former only interest us here. In the moveable joints, we find—1. cartilages of incrustation, covering the extremities of the opposing bones; 2. a synovial membrane, expanded over the articular surfaces—it secretes the synovia, or joint-oil; 3. ligaments of various forms, to strengthen the joint, and to assist in maintaining the bones in apposition. These ligaments are of various forms, but may be described either as orbicular, or circular, as in the hip-joint, or cordiform—*i. e.*, rope-shaped—as in the elbow and knee-joints. In addition to these structures, there are fibro-cartilaginous discs, called interarticular ligaments, placed, as it were, in the interior of the joint (but not within the synovial membrane), in certain articulations, as in that of the lower jaw and the knee-joint.

It will be readily understood, by examining the articular surface of a bone, to what description of articulation the surface belongs. Some rotate in nearly all directions, as the head of the humerus, or arm-bone, and that of the femur, or thigh-bone; others are evidently confined to a hinge-like motion, as the tibia and ulna. The hip-joint presents the only true ball and socket joint found in the body.

C. Of the Muscles; their Anatomy and Physiology.

By the action of the nervous system, acting through

the will or otherwise, the masses of flesh called muscles are made to contract or shorten themselves, and by this contraction or shortening, the levers to which they are attached are made to approach or recede from each other (Pl. 5, 6, and 7). The whole phenomena of locomotion, of muscular action generally, and of the voice, depend on this single phenomenon, the contracting or shortening of the muscular fibre under the influence of the will, or when acted on by other excitants. I shall, in describing the muscles briefly, give, at the same time, an outline of their simple and combined actions. The dissected Plates in the Atlas accompanying this work, furnish very favourable views for the right comprehension of this system of organs, anatomically and physiologically; and by combining their physiological actions with the anatomical details, I hope to render this—the driest and least interesting subject, perhaps, in one sense, of the anatomy of the body—if not more agreeable, at least less tedious to the general reader.

The artist will find it to his advantage to sketch the human muscles carefully; but after having done so, it will be well for him to recollect, that in the "Liber Studiorum" of Leonardo da Vinci, which I examined in the Queen's Library at Windsor, that great man and inimitable artist took the greatest pains to correct his ideas, in respect of external forms, by sketching the entire and living arm uniformly with the dead and dissected one—in order, apparently, that he might, under no circumstances, mistake the one for the other, and thus place before the eyes of the spectator, anatomical—that is, dead and dissected—shapes, for the living and real external

forms of the human body, such as nature intended they should ever appear to man.

Turn, now, to Pl. 6, Fig. 1, of the Atlas, and observe that, the anatomist having removed the integuments, cellular and fatty envelope, and fasciæ,* whether simply cellular, as on the trunk, or strongly fibrous (*aponeuroses*), as in the limbs, displays thereby the first layer of muscles on the left side of the figure, and by removing these, still deeper layers on the right side.

Fig. 1, Pl. 6, left side of the figure:—

Most of the muscles exposed are named on the Plate; their chief action is to maintain the body erect, and to extend the limbs. But powerful flexors are also to be met with on this aspect of the body, as those seen on the back of the thigh, which bend the leg on the thigh. The student will observe, that as the viscera lie mostly towards the front of the body, so the erector muscles on the back must be proportionally strong to resist and overcome the weight of the viscera in front. The muscles on the back of the neck are especially strong in man, and remarkably so in the athlete, or prize-fighter. So also are the muscles of the shoulders. In this view are displayed the muscles called glutei and gastro-cnemii, which, from their great strength, enable Man to stand erect with such ease.

Whilst studying Pl. 6, devoted to the muscular system, the attention of the reader may with propriety be directed to the figures it contains; they refer to matters which are

* Fascia: a binding, or roller; a word applied by anatomists to certain cellular and fibrous layers enclosing the muscles; when they enclose other parts, as the glands, they are called capsules.

common to the muscular system, wherever placed. Fig. 2 represents the muscular fibre, as seen under a microscope of high powers. The muscular fibres which obey the will are striped, an appearance not found in the muscular layers belonging to the intestinal tube, stomach, &c.; hence their fibres are called unstriped; but this law offers many exceptions. Figs. 3 and 4 explain the advantages we derive from the insertion or attachment of the tendons of muscles near the joints, instead of at a greater distance; the nearer the point of insertion is to the fulcrum, the wider will be the space through which the same force employed carries the lever in motion, and, consequently, the resistance, whatever that may be, which is to be overcome. Fig. 4 represents a double-bellied muscle, like the biceps of the arm, dissected and removed from all its attachments to show its form. Fig. 5 displays the rounded form of other muscles. Fig. 6 shows the outline of a complete penniform muscle; and Fig. 7, that of a semi-penniform muscle. In Figs. 8 and 9 are shown the actions of raising and pulling weights.

To return to the arrangements of the muscles, the layers they form, and the actions they give rise to through the influence of the will, let the student turn next to Pl. 7, one of the most valuable and useful plates which can be placed before him. In Fig. 2, he will find, first, a representation of the muscles of the superficial layer of the head, neck, trunk, and haunch, as seen on the right side. The leading muscles are named as follows: *t.* the temporal; *m.* the masseter; *s.* the sterno-mastoid; *d.* the dernoid; *p.* the great pectoral muscle; *o.* the

aponeurosis, or tendon of the external oblique muscle of the abdomen. On raising the first layer up—that is, on dissecting the plate—the opposite side of the layer displays the deep muscles found in the interior of the walls of the chest, abdomen, and pelvis. A still deeper dissection shows the corresponding muscles, as well as others, on the inner side of the left side of the trunk, neck, and pelvis.

In Pl. 8, Fig. 1, will be found the muscles which move the eye-ball; and in Pl. 5, Fig. 1, most of the muscles found on the front of the body, limbs included.

In Fig. 1 of this plate, most of the muscles are named on the figure, and their English names given in the Atlas. On this aspect are found the muscles which bend the head forwards, which curve the trunk in the same direction, and which flex the fore-arm and hand. In the lower extremities are seen the great extensors of the leg on the thigh (rectus, &c.), and of the foot on the leg. The other figures have a reference to the different kinds of levers found in the human body.

Portions of the muscular system of locomotion are scattered through various plates of the Atlas, but it is not necessary to allude to them further in this place. The following outline will be found useful to those who may be desirous of further information on a subject which most view as, upon the whole, too technical and devoid of general interest. A Chapter on the general movements and attitudes of the body will be found in Part III.

Tabular View of the Arrangements of the Muscles, in Regions.

Muscles are found—1. In the head and neck, in the following regions:

a. Epicranial.
b. Auricular.
c. Eyelids and orbits.
d. On the face.

2. In the neck:

a. Anteriorly.
b. Posteriorly.
c. Deep muscles, belonging to the palate, pharynx, gullet.

3. In the trunk:

a. Anteriorly.
b. Posteriorly.
c. Deep-seated.

4. In the pelvis:

a. External.
b. Internal.

5. Muscles of the superior extremities:

a. Of the shoulder.
b. Arm.
c. Fore-arm.
d. Hand.

6. Muscles of the lower extremities:

a. Haunch.
b. Thigh.
c. Leg.
d. Foot.

The general plan of the muscles is the same in all mammals, but they vary much in form, size, and other arrangements. They constitute the *flesh* of animals, and form the chief nutriment of Man. Every species seems to have a distinct flavour attached to its muscles, and this flavour may be influenced by the food last used by the animal.

In addition to the systems thus described as being placed in relation to, or under the dependance of the nervous system, there are others which may with propriety be noticed here. To prevent the evil effects of

friction, we have seen that Nature has constructed the joints, providing them with a joint-oil equal to meet all the ordinary and even extraordinary efforts of the animal. The most fatiguing march does not exhaust it; neither does it fail the antelope in its rapid course, nor the ostrich. To protect certain portions of the integuments more exposed than others to pressure, nature has placed the subcutaneous bursæ (little bags, containing synovia—*i. e.*, joint-oil) between the integuments and the fasciæ, or aponeurosis, and by this simple contrivance enables Man to rest on the knees, elbows, and outer ancles for a longer or shorter period, without any injury to the sensitive integuments, placed between them, and the hard body on which they may be resting. Other bursæ are placed more deeply between tendons and bones, or even between one tendon and another, for the same purpose.

Moreover, the muscles are enclosed in sheaths of cellular membrane, which readily permit of the contraction and expansion of their fibres. Strong and fibrous aponeuroses, or membranes, also enclose them in the limbs, retaining them in their place. Physiologists are generally agreed, that the muscular fibre, when it has been destroyed by disease or otherwise, is never restored, but, in its place, a substance is deposited, resembling tendon, or aponeurosis.

CHAPTER VI.

THE LARYNX, OR ORGAN OF VOICE.

Anatomy.—In immediate connection with the nervous system and the reasoning powers, are the organs of voice.

Numerous experiments have left no doubt that the larynx is the organ of voice; the organs of speech are all the parts situated between the vocal cords* and the lips. The larynx (Pl. 3, Fig. 1, and Pl. 4, Figs. 1, 6, and 7) surmounts the trachea, or wind-pipe. It is a short tube, strongly connected to the surrounding parts. A skeleton composed of cartilages forms its frame-work, and gives attachments to its various muscles; of these, some are extrinsic, others intrinsic. The cartilages are the thyroid, cricoid, arytenoid (two in number), and the epiglottis. In the interior (Fig. 7, Pl. 4) of the larynx are placed the true vocal cords; the air, in passing from the lungs, impinging on these cords, gives rise to the voice. One of the functions of the epiglottis is to close the superior opening of the larynx during deglutition, so as to prevent the food, liquid or solid, from entering it. Four nerves, called laryngeal, supply it with nervous influence, and numerous muscles act upon it, both as a whole, and on its individual parts. Being intimately connected with the base of the tongue, the larynx follows its movements.

The larynx is larger in man than in woman, and the thyroid cartilage, by its salient angle, projects in many men very strongly on the front of the neck. The vulgar name given to it is the *pomum Adami*. A mucous membrane, continuous with that of the mouth and nostrils, lines the interior of the larynx and wind-pipe.

Physiology.—The Voice.

The vocal organ of man and the higher animals, may be best compared with a tongued instrument. The carti-

* Elastic cords placed in the interior of the larynx.

lages form the box or case, in which the tongues are fixed. As the musician tunes his instrument by increasing or diminishing the tension of its vibrating strings, so something like this takes place with the tongues, or vocal cords of the human larynx. This is effected by small muscles acting on the very moveable arytenoid cartilages to which these cords are attached. Hence the cords are rendered tense or loose as required. By their means, also, the width of the vocal fissure is altered, and thus man sings or speaks at will, tuning his instrument to any pitch of which it is capable.

Many of the vocal operations have been verified on the dead larynx, the elasticity of the vocal cords not being dependent on life. Ordinary vocal sounds are produced at the moment of expiration; but expiration is not essential to the production of voice. A good singing voice includes about two and a half octaves; but distinguished female singers possess an octave more. The glottis (the vocal fissure between the vocal cords) and the more or less moveable pieces of the double body-tube formed by the cavity of the mouth and nose, together, produce the various sounds of speech. But as all these structures are present in the higher animals as well as in man, and yet they are devoid of speech, the result cannot depend on these minor peculiarities in the organs of speech, but in the superior development of their nervous systems.

In deaf and dumb persons the organs of speech are in no way defective; the cause of their dumbness lies in their inability to perceive sounds.

PART II.

ON THE ORGANS OF VEGETATIVE OR ORGANIC LIFE.

The functions and organs just described, constitute the amimal properly so called. They establish his relation with the external world, and their exercise is associated in the minds of all that lives with life itself. What moves not, nor feels, is considered as dead in man and animals. But in order to maintain a machine so complex, subject to a perpetual tear and wear, an entire series of organs and functions, of great complexity, became necessary. To this series the illustrious Bichat gave the name of vegetative or organic, inasmuch as they more resemble what we meet with in the vegetable kingdom. The name, it is true, is open to many objections, but no more appropriate one has as yet been substituted.

CHAPTER I.

OF THE ORGANS OF DIGESTION.

The great object of the series of functions I am now about to consider is *nutrition,* or the nourishment of the body, and the supply of the waste incessantly going on in every thing that lives. This supply is drawn from the food. The object is to form the arterial blood out of which, seemingly, all the tissues are formed by a process, as yet, not at all understood. Nevertheless, nutrition is the ultimate aim of all the functions I am now about to

speak of, (including that of respiration), as well as of those which remove from the blood the effete or useless elements; for unless these be withdrawn, the blood could not, as experience demonstrates, be preserved in a state of purity.

Physiological Classification of the Organs of Digestion.

Systematic anatomists include under the name of Organs of Digestion, the following organs. (Pl. 7, Figs. 3, 4, 5, 6, and Pl. 1 and 2).

1. Organs of prehension—the mouth and lips.
2. Organs of mastication—the teeth.
3. Organs of salivation—salivary glands.
4. Organs of deglutition—pharynx and gullet.
5. Stomachal digestion—the stomach.
6. Intestinal digestion—small and large intestines.
7. Glandular appendages of the digestive tube—liver, spleen, and pancreas.

All these organs play a part in the digesting of the food, or in preparing it for digestion. They are not, it is true, all present in every animal, nor even in every mammal, but we find them in man, whose structure and physiology form the object of this little volume.

In this section as in the preceding, I shall generally describe, in the first place, the anatomy of the organs, and secondly, speak of their functions. The reader is recommended to have the dissected plates constantly before him, and thus avoid all misconception as to the form, position and relative bulk of the organs. A few remarks on the nature of the food, may with propriety form an

introduction to the anatomical and physiological details about to follow.

Of the Food.

The food, whose great object is to replace the compounds which have been rendered useless, or have been expelled from the body, and to furnish under certain circumstances, a surplus applicable to the growth or increase of the frame requires to be transformed into definite organic compounds. Now all experience seems to show that the individual can only be sustained by an organic, and not by an inorganic food; nevertheless these inorganic substances are not useless. Common salt and water are essential to the digestion of the food; yet these are quite inorganic.

Man derives his food usually from the vegetable and animal kingdoms, but there are races of men who seem to live solely on vegetable food, and others who subsist as exclusively on animal diet. The Esquimaux use no vegetables, and the wild Bosjieman of Southern Africa, resort to them only in cases of necessity. What is sufficiently remarkable is that no inference can be drawn from the character of the human teeth as to the nature of the food it was intended man should live on, and the same remark applies to the form of his stomach.* Thus the human structure violates those anatomical relations on which the celebrated Cuvier founded, as many think, most of his views or theories, and by which he was led to so many discoveries.

* That is, there exists no anatomical or physiological co-relation between them.

A mixed diet seems most appropriate, however, to man; it is this diet which contains ternary aud quaternary organic compounds in sufficient quantities. Most substances which nature offers as food, (even the potato), belong to this mixed class; the flesh of animals itself belongs to this mixed class, some fat cells, whose oily contents are composed of carbon, hydrogen, and oxygen, being interposed between the highly azotized muscular fasciculi or bundles.

The imperious sensation of hunger is referred to the stomach; that of thirst to the mouth and throat. Some persons never feel thirst. Water enters largely into the composition of various kinds of food; but this does not explain the fact why some animals, as the llama, seem never to drink.

Milk fulfills all the conditions required of food; its casein represents the albuminous substances; the sugar of milk, the hydrates of carbon; its butter, the fatty matters; and its ashy compounds those mineral bodies which are independantly necessary, or are usually introduced as a relishing addition to the food. On the other hand, vegetable aliments in their original form are considered incapable of affording a permanent foundation for the chemical construction of the animal tissues. Albumen, fibrin, and casein, constitute the essential conditions of animal maintenance and growth. Blood itself, which theoretically ought to form one of the very best varieties of food, is rarely made use of as food. It is probable that instinct, fashion, and other accidental circumstances, exercise considerable influence in the selection of food, whilst as

regards individuals, peculiarities of constitution must be taken into account.

Physiologists seem to think that adult man may live about three weeks without any kind of food; but it is probable that most would perish after a fast of nine days.

CHAPTER II.

ORGANS OF PREHENSION ; LIPS, TONGUE, AND MOUTH GENERALLY.

The common integuments of the face, as they approach the margins of the lips and nostrils, begin to lay aside their character of integument, or external envelope, and to assume that of mucous membrane, or internal integument. It has already been shown how the portion lining the interior of the nostrils, proceeding backwards, becomes, or is continuous with, that investing the pharynx and gullet; the same happens with that lining the buccal* cavity, which, at the isthmus faucium,† is also continuous with that of the pharynx. But here, the membrane divides into two great portions: one, namely, which, passing into the larynx, becomes the lining membrane of the organs of respiration —this has been already spoken of at p. 53; the other, descending into the stomach by the gullet, may be traced con-

* Buccal: of, or belonging to, the mouth.

† Isthmus faucium: the narrow passage between the mouth and the pharynx, the cavity surmounting the top of the gullet.

tinuously to the termination of the intestinal canal. It is the latter of these divisions which now remains to be examined.

I.—Organs of Prehension; the Mouth, Lips, Tongue, and Tonsils.

The mouth, which varies so much in different individuals, is a nearly oval cavity, placed horizontally, comprised between the two jaws, bounded laterally by the cheeks, anteriorly by the lips, posteriorly by the velum palati* and the pharynx; above by the arch of the palate, and below by the tongue. The mucous membrane may be traced on the free edge of the under lip, of which it lines the posterior surface, to be afterwards reflected upon the body of the maxillary bone; there it forms, opposite the symphysis† of the chin, a fold, more developed below than above, named the frænum of the under lip, which is lost insensibly upon the lip. The membrane then sends into each alveolus‡ a prolongation which strengthens the insertion of the roots of the teeth, and is continuous with a membranous lamina which lines these cavities. From thence it proceeds over the posterior surface of the frænum

* Velum palati: veil of the palate, a membranous and muscular partition, which divides the mouth from the pharynx; it is suspended to the margin of the osseous, or hard palate, and is extremely moveable. The uvula forms a portion of the velum palati, being suspended from the middle of its free edge. The organ may be readily seen by looking carefully into the mouth. The defect called cleft-palate is a congenital (original, or from birth) deformity of the structure I now describe.

† Symphysis: a union, joint, or articulation. It may be either a *bony* union, as that of the chin, or a cartilaginous and ligamentous union, like the pubes.

‡ The osseous cavity containing the root of the tooth.

of the tongue, covers that organ, gains the epiglottis,* and is continued into the mucous membrane of the larynx and pharynx.

Superiorly, it (the mucous membrane) commences on the free edge of the upper lip, forms between it and the superior maxillary bones a frænum, gains the upper alveolar arch, sends prolongations into the corresponding alveoli,† passes to the vault of the palate, of which it closes the anterior and the two posterior foramina (holes), receives the nerves and vessels which pass through them, and is reflected over the fore-part of the velum palati, on the free edge of which it is continuous with the pituitary membrane. On either side this membrane, proceeding from the commissure‡ of the lips, lines the cheeks, proceeds over the branch of the inferior maxillary bone, forming a vertical fold opposite their anterior edge. At the backmost part, it turns over the constrictor isthmi faucium§ and palato-pharyngeus muscles,|| to form the pillars of the velum palati, between which it covers the tonsils. Beyond this, it is continuous with the membrane of the pharynx. The mucous membrane of the mouth varies in structure, and is covered with a distinct epi-

* Epiglottis: the small triangular-shaped cartilage protecting the entrance into the larynx, or organ of voice.

† Alveolus: the bony cavity for the reception of the roots of the teeth.

‡ Commissure: a junction, or joining.

§ Constrictor isthmi faucium: a muscle so named, its function being to contract still more the narrow passage just described.

|| Palato-pharyngeus muscle a muscle so named, from being connected with the moveable palate and the bag of the pharynx.

thelium—that is, a kind of epidermic covering. The tonsils (amygdalæ) are bodies lodged between the pillars of the velum palati. They represent an ovoid, of which the large extremity, directed upwards, corresponds to the point at which the pillars meet, while the small extremity, which looks downwards, rests upon the base of the tongue. Their external surface adheres to the constrictor pharyngeus superior muscle; the internal, convex and free, projects, and constitutes the sides of the isthmus of the fauces; their anterior edge touches the constrictor isthmi faucium muscle; the posterior touches the palato-pharyngeus. They are divided into several lobes, and have a greyish colour, and appear formed by a pulpy tissue resembling that of mucous follicles. They are filled internally by cellules, open on their inner surface, whose orifices are large; the mucous membrane of the mouth lines their wall. In the bottom, excretory ducts are observed to open from a mass of follicles, forming the substance of the tonsil externally. The arteries of the tonsils come from the lingual inferior palatine, and internal maxillary arteries. Their nerves come from the lingual and glosso-pharyngeal.

The tonsils are the seat of the common inflamed throat, and of a variety of affections included under the name of sore or inflamed throat. They sometimes grow to a very large size, and are frequently removed, for this reason, by surgeons. When very large, they are supposed to obstruct the passage of the air to the lungs; but I have never observed the occurrence of any such inconvenience, and their indiscriminate extirpation has always appeared to me unnecessary, and even a questionable practice.

The tongue* is very moveable, and extends from the hyoid bone to behind the incisive teeth; it is used in sucking, mastication, deglutition, speaking, &c.; it has two surfaces, two edges, and two extremities. The upper surface is entirely free, flat, covered by the mucous membrane of the mouth, with a groove running along the middle, and dividing it into two equal lateral portions. Towards the back part of this surface, there is a depression, called the foramen cœcum (the blind foramen, or hole); from this point, two lines, formed of papillæ, proceed forward, diverging from each other. All this surface of the tongue is rough with nervous papillæ. The fore part of the tongue is called the apex, the central part the body, the posterior part the base. The apex is free anteriorly; the body and base are fixed by numerous and powerful muscles to the inferior maxilla and hyoid bone; the edges are also free. The mucous membrane covering the upper surface of the tongue passes from it uninterruptedly upon the epiglottis.* Three folds may be observed here, one mesial, and two lateral; these are called ligaments of the epiglottis. The tongue is very thick at the level of the foramen cœcum, but it becomes thinner as it approaches the hyoid bone; its apex, inferiorly, is fixed to the inferior maxilla by the frenum linguæ, a fold of mucous membrane.

* Pl. 8, Fig. 11; also Pl. 1 and 2; *l*, on the reverse of the figures; the letters *e*, *p*, which point to the epiglottis, are placed on the base of the tongue.

† Epiglottis: see note p. 60.

II.—Organs of Mastication.—The Teeth (Pl. 7. Figs. 3, 4, 5).

In the course of life, man has two sets of teeth: 1. the temporary, deciduous, or milk-teeth; 2. the permanent. The temporary are twenty in number; the permanent, thirty-two. Each jaw carries the same number. Deficiencies are not infrequent, and supernumerary teeth have also been observed.

General Characters.—The human teeth differ, in this, from all other existing species of animals—that, although comprising three different kinds, their summits are still on a level.*

Each tooth has its own peculiarities, but still there are structures and circumstances common to all. Each, for example, has a corona, or crown, projecting above or beyond the gum; a narrow constricted part follows it, called the neck, cervix; and a third, the radix, root, or fang, is implanted in the alveolus intended to receive it. Each alveolus is invested by a vascular periosteum, which is reflected over the fang as high as the neck. The permanent teeth, thirty-two in number, sixteen in each jaw, are divided (above and below) into four incisors, two canine, four bicuspids,† or small molars, and six true molar teeth, or multicuspids. Among the temporary teeth, there are no bicuspids. The incisors are chisel-shaped, and have a sharp horizontal cutting edge; this

* In the extinct anaplotherium this peculiarity also existed.

† Bicuspids: teeth with two projecting tubercles, or cusps, on the grinding surface. Multicuspids, or multicuspidati: teeth with several tubercles on the same surface.

becomes bevelled off, and worn away by trituration during life. Before the wearing takes place, the edge is slightly serrated, or notched; for it must be borne in mind that, the instant a tooth cuts the gum, it begins to lose its original form. The fang of the incisors* is single, long, and conical. The upper and lower incisors differ in form. The canine teeth,† four in number, follow the incisors; they are larger and stronger, and have been called cuspidati. The fang is single, conical, and strong. A slight groove is seen on its sides. The small molars (bicuspidati) are four in number in each jaw; they follow the canine. The corona is surmounted by two tubercles, or cusps, and the fang has a tendency to divide into two. The apex of the fang is bifid. The upper bicuspids are larger than the lower.

The true or large molar teeth, or multicuspids,‡ are twelve in number, three on each side in both jaws. The first is the largest, the third the smallest. This is called the wisdom tooth. It often appears late in life. The upper true molars have, on the corona, four cusps; the lower ones, five. The fangs are multiple, being two or three. The milk-teeth should be carefully looked at whilst entire, and in the jaws; they are smaller than those which follow. The last molar is the largest of these teeth, and the corona exceeds in size the permanent bicuspid which is to follow it. Moreover, the milk molar teeth are not bicuspids, but resemble, by their coronal surface, the permanent multicuspidati.

Structure.§—When a tooth is divided vertically, it is

* Fig. 3, Pl. 7. † Fig. 4, Pl. 7. ‡ Fig. 5, Pl. 7.

§ The true history of the human dentition was discovered by Hunter;

found to be hollow in the centre. This hollow occupies the interior of the corona, and extends as a canal to the apex of the fang, where it opens on the surface. This central cavity is called the pulp cavity, being filled with the dental pulps (dentar vitrine), a vascular and highly sensitive pulpy substance. The vessels and nerves reach the pulp by the canal and aperture in the fang.

The solid portion of the corona of the tooth is composed of three distinct substances, namely: 1. the ivory; 2. the enamel; 3. the crusta petrosa, or cement. Of these, the first, or ivory of the tooth, lies deepest, and forms by far the largest part of the tooth. The second, or enamel, covers the corona and tubercles, or free surfaces; the third is a thin layer of a peculiar substance, investing the ivory of the fang, in man, but, in many animals, extending over the whole of the corona.

The ivory is dense and compact, resembling compact bone, but it is not identical in structure. It is composed of 28 parts of animal matter (gelatine), and 72 of phosphate of lime, with traces of fluoride of calcium, carbonate of lime, phosphate of magnesia, and other salts. When examined under the microscope, the ivory structure of the tooth is found to be composed of innumerable fine tubes, passing through a matrix, or dense intermediate or intertubular tissue. The dental tubuli were discovered by Looewenhoek, and again described by Purkinjie and Retzius.

The tubes, or tubercles, open into the central cavity of

that of other mammals by Cuvier; their intimate structure by Loewenhoek and Retzius.

the tooth, and pass in a radiated manner to the periphery* of the ivory. From these primary tubes, as they may be called, spring branches of inconceivable fineness, which penetrate the intertubular tissue; they are supposed to end in minute cells; the tubes themselves also divide and subdivide before they reach the periphery; they are generally considered, also, as passing into the cement.

The intertubular substance is translucent, and finely granular; its precise nature is still doubtful. The enamel is the hard, white substance encrusting the crown of the tooth. Though extremely hard, it becomes worn by trituration. When the tooth is charred, the dentine blackens, but the enamel remains white. It has 96·5 per cent. of earthly constituents; the remaining 3·5 of animal substance. It is made up (Retzius) of very hard and dense microscopic fibres, or prisms, arranged closely together, side by side.

The crevices observed in the enamel, running so deep as sometimes to reach the ivory of the tooth, are supposed, by some, to contribute to the formation of caries, or decay. The prisms composing the enamel are conjectured to be originally formed in cells, the membranous walls of which gradually disappear. The crusta petrosa is best seen on the molar teeth of the elephant. In man, it forms an extremely thin covering, investing the fang, but probably, at first, extending over the corona and neck. It contains cells and canaliculi, and its structure more resembles bone than does the ivory of the tooth. It is now considered as a layer of true bone, distinct from the other

* Periphery: circumference.

component parts of the tooth in this respect. Towards the lower end of the fang, it becomes thicker, and, at last, occasionally closes the orifice at the apex leading to the central cavity.

Fourth Substance in Teeth.—With age, the central cavity diminishes, by the growth of a substance viewed by Cuvier as a further ossification of the pulp; but a careful examination of this substance in the teeth of the cachalot, and some other animals, led me, some years ago, to view this substance as a fourth component part of a mammal's tooth.

It is, probably, a modification of the bony structure, and forms, in all probability, the greater part of the structure of the teeth in fishes, serpents, and reptiles generally.

Development of the Teeth; their origin and growth; the order in which they appear; the mode of formation of the tissues; the ivory, enamel, cement, and central bony tissues.—The teeth were long ago said, by De Blainville, to resemble the bulbs of the hair; this comparison is exact, and contains the whole philosophy of their development.*

At first, the jaws present no appearance of alveoli.

After a time, a wide groove appears along the edge of each jaw; this gradually deepens, and is, at last, divided by bony partitions into a series of four-sided cells. This happens about the fifth month of fœtal life.

As regards the mucous membrane in which the teeth are developed, about the sixth week of embryonic life a

* As explained, in all its details, by my esteemed friend and former student, Mr. J. Goodsir.

groove appears in the mucous membrane of the gum; this is the primitive dentar groove.

A series of ten papillæ grow from the bottom of this groove in each jaw; these constitute the pulps, or germs of the milk-teeth. By the tenth week, all these papillæ are completely formed. This has been called the papillary stage. A second follows, called follicular, in which the papillæ grow rapidly, assume individual forms, and project from the papillæ. This stage is complete about the fourteenth week. A third stage follows, to be completed about the end of the fourteenth week. In this stage, the groove is gradually obliterated, and the follicles are converted into closed sacs.

The dentar sacs thus formed continue to enlarge.

The walls of the sacs consist of an outer fibro-cellular layer, and an inner vascular.

The dentar pulps adhere, by a broad base, to the bottom of the sac: and, now, resembling strictly the crowns of the future teeth, the hard substance begins to form in them. By the end of the fourth month, thin cusps, or shells, are formed on all the pulps of the milk-teeth, presumed to be the ivory substance. This continues to increase in thickness, constricting the pulp, and, seemingly, growing at its expense.

In the mean time, the enamel is being formed and deposited on the ivory by the parietes of the sac adapted to the outer side of the pulps. Sooner or later, the part of the crown so encrusted with enamel appears through the gum, the other processes going on until the fang be also formed.

These facts, and many others connected with the formation of the teeth, were first clearly demonstrated by Cuvier on the teeth of the young elephant, and applied analogically to the human teeth; but he did not understand the true structure of the teeth, which was afterwards discovered by Retzius.

Formation of the Hard Tissues of the Teeth; Theories.—It was, at first, supposed that the ivory was formed by a process of ossification similar to what takes place in bones.

This theory gave way to the Cuvierian, which viewed the ivory as a secretion, in layers, from the surface of the pulp, the enamel being deposited over it by the inner side of the enveloping capsule. The former, or first opinion, has been revived by Schwann, Purkinjie, and Raschkow; they view the ivory merely as an ossified pulp. The whole theory is still doubtful.

There is one thing which I think certain, namely, that a delicate membrane encloses the pulp, which, perhaps, is the first to ossify; but even this is doubtful; for it has always appeared to me that the cap of ivory is exterior to the investing membrane of the pulp. Thus, the nature of the tubuli and of the intertubular matrix is not well understood.

The Enamel.—A peculiar organ is developed in the outer wall of the dentar sac, and by this the enamel is secreted. Hunter describes this perfectly. Whilst the enamel is being formed, it is soft and chalky, and easily broken down. The examination of this peculiar organ forming the enamel, even under the most powerful microscopes, has failed in detecting its intimate nature.

The Cement.—This layer, secreted, probably, by the periodontoid* portion of the periosteal† covering of the alveolus, forms simultaneously with the ivory. The coronal cement is supposed to be formed by the same membrane secreting the enamel.

First Dentition.—This commences at about the seventh month, and is completed about the second year. The central incisors of the lower jaw appear first; next those of the upper. As the tooth is about to cut the gum, this latter alters its character. The nature of the small white bodies with which the mucous membrane is studded, just before the eruption of the tooth, has not been ascertained.

Second Dentition.—The teeth of this dentition grow in the same way as those of the first. The sacs and pulps of the ten anterior permanent teeth are formed behind those of the first set, and before birth.

The sac of the permanent tooth adheres to that of the corresponding deciduous‡ one. They are, at length, separated from each other by a bony partition, each, thus having its own alveolus. A solid membranous pedicle connects the sac with the gum, then passes through an opening in the bone. As the permanent tooth rises through the gum, it presses on the bony partition separating it from the milk-tooth, and assists in destroying it.

* Periodontoid: what surrounds the tooth.

† Periosteal; periosteum: the membrane surrounding bone; perichondrium: the membrane investing a cartilage.

‡ Deciduous: destined to fall; a term applied to the first set of teeth, which are also called milk-teeth. Those succeeding them are called permanent, as being intended to continue throughout life.

Thus, the milk-tooth losing its support, becomes loosened, and falls out, or is removed, the permanent tooth taking its place.

The large permanent molar teeth, six in each jaw, are not preceded by any deciduous teeth; but their mode of formation from a papilla and sac does not seem to me materially to differ, in other respects, from those in front of them.

The papilla which is to form the anterior large molar tooth, appears about the sixteenth week of fœtal* life; at the seventh month after birth, the papilla of the second large molar appears; and about the sixth year, appear the rudiments of the sac and papilla of the wisdom-tooth.

SECOND, OR PERMANENT DENTITION.

First molar		6th year.
Incisors: central. . . .		7th ,,
,, lateral . . .		8th ,,
Bicuspid: anterior . . .		9th ,,
,, posterior . . .		10th ,,
Canine . . .	11th to	12th ,,
Molars: second . .	12th to	13th ,,
Third, or wisdom-tooth .	17th to	25th ,,

In consequence of these changes in the number of the teeth, the jaws undergo remarkable alterations in form; the alveolar arch alters its shape, but the segment of the arch which it forms anteriorly seems almost as large in

* Fœtal: a term applied to the child before birth. Fœtal life endures for nine months.

the child as in the adult. The angle of the lower jaw is obtuse in the child, and in the very aged person; it approaches a right angle in the adult.

The question of the presence of blood-vessels in the hard substance of the teeth is still somewhat undecided; the evidence, however, is all against the extension of blood-vessels into any portion of the enamel. In some respects, the teeth resemble the lens of the eye.

It is possible that in very young animals, blood vessels which afterwards become obliterated, extend a short way into the ivory; but this has never been proved.

The results of the latest microscopic inquiries tend to establish certain analogies between tooth and bones; but the comparisons hitherto made are coarse, and have not a sufficiently extended base: that base must be sought for in philosophic anatomy. The nature of the tartar which grows on the human teeth has not yet been determined.

III.—Organs of Insalivation and other Mucous Glands.

The *salivary glands* are symmetrically placed to the number of three on each side of the face, behind and beneath the lower jaw. Their form is, in general, very irregular, and their extent varies much in different subjects. Sometimes they are perfectly distinct and isolated;* at other times they seem to be confounded with each other. But they all present characters which are common to them, and which serve to distinguish them from other glands of the body.

* Isolated: standing apart.

Thus their vessels penetrate them on all sides, and are already much ramified before arriving in their parenchyma;* while the liver, the spleen, and the kidneys receive theirs by a determinate point, and under the form of more or less voluminous trunks.

They are supplied with a considerable number of nervous filaments from the encephalic system;† while the liver has but a very small number of such nerves, and the kidneys none at all.

Their colour is grayish, their tissue firm and strong; the granulations of which they consist are successively united into lobules and irregular lobes, which gives them the greatest resemblance to the pancreas and lachrymal gland. They are enveloped by no particular membrane, as is the case with the liver, the kidneys, &c. They merely seem surrounded by a thin layer of cellular tissue, destitute of fat, and very different from the fibrous membranes.

Lastly, their excretory ducts all open in the interior of the mouth, without any intermediate reservoir, while the tears, the bile, &c., are contained for some time in a reservoir before arriving at their destination.

* Parenchyma: an obscure term, much used by the older anatomists and physiologists, and applied by them generally to the solid mass of the glands.

† Encephalic: of, or belonging to, the brain, which is also called encephalon—that is, within the head.

Of the Salivary Glands in particular.

The Parotid Gland.

The *parotid gland* is the largest of the salivary glands. It is situated partly before and partly beneath the external ear, filling up the deep excavation on the sides of the face, between the posterior edge of the ramus* of the lower jaw, the external auditory passage, and the mastoid process of the temporal bone. It extends vertically from the zygomatic arch to the angle of the jaw. Its form is that of a very irregular pyramid, with an oval base directed outwards. The parotid gland furnishes, by each of the granulations of which it is composed, a very slender excretory duct, which unites with those in its vicinity, in the manner of veins, to form somewhat larger twigs, then branches, and lastly, a considerable trunk named the parotid duct or Steno's duct (ductus Stenonianus). This duct emerges from the fore and outer part of the gland, a little above the middle of the height of the masseter muscle, (*m*, Fig. 2, Pl. 7), over which it proceeds horizontally, from behind forwards, to turn over its anterior edge, and sink into the adipose cellular tissue of the cheek. Having arrived upon the buccinator muscle (forming the fleshy mass of the cheek), it passes through an aperture formed in the midst of its fibres, and terminates in the mouth, opposite the second molar tooth of the upper jaw, at the distance of about three lines from the meeting of the cheek with the corresponding gums.

* Ramus, or branch.

The parotid duct does not pass through the buccinator obliquely, but perforates it perpendicularly, and forms an angle as it passes through the mucous membrane of the mouth, proceeding a little forwards. Its orifice is, besides, very contracted, and furnished with a small fold of the mucous membrane, so that it is not easily perceived.

Submaxillary Gland.

This gland is smaller than the parotid, and is situated at the inner side of the ramus, and body of the inferior maxillary bone, in the triangular space which the two bellies of the digastric (double bellied) muscle leave between them. Irregularly ovoidal and flattened on their surfaces, frequently bifurcated in its fore part, it is prolonged externally as far as the angle of the jaw, and is sometimes confounded in this direction with the parotid gland.

The excretory duct of the submaxillary gland is commonly designated by the name of Wharton's duct (ductus Whartonianus). It is much smaller than Steno's duct, and has much thinner walls, which are transparent and more elastic. When it has arrived upon the side of the frænum linguæ, it places itself beneath the mucous membrane of the mouth, and terminates in this place by a very narrow orifice, situated in the middle of a slightly prominent tubercle.

The *sublingual gland* is placed in the substance of the inferior wall of the mouth, under the fore part of the tongue, and seems, in general, to be merely a sort of appendage to the submaxillary gland. Its position is

nearly horizontal, and its direction parallel to that of the opposite side. It is smaller than the submaxillary gland, of an oblong form, with its greatest diameter from behind forwards, transversely flattened, and nearly of the shape of an almond.

This gland has several excretory ducts, whose disposition is liable to much variation. These are always very slender. Six or eight proceed from its upper part to open upon the sides of the frænum linguæ, while five or six others issue from its lateral parts, and perforate singly the mucous membrane of the floor of the mouth. Two, three, or even a greater number are also seen to end in the submaxillary duct; those latter are very short and frequently unite into a single trunk before terminating. All these ducts appear to have the same structure as that of the submaxillary gland, and, like it, are thin and transparent.

IV.—Organs of Deglutition. (Pl. 1 and 2).

On the reverse of the figure of the head will be seen in both Plates the pharynx and commencement of the gullet.

The pharynx is a muscular and membranous bag, placed in the median line of the body, and somewhat funnel-shaped; it extends from the base of the cranium, in front of the vertebral column, to about the fourth or fifth cervical vertebra.

The palate (seen in both plates, but not numbered) is the upper wall of the mouth, limited anteriorly by the adhering edge of the upper lip, posteriorly by the base of

the velum palati (pendulous palate), and laterally by the cheeks. A white line, slightly depressed, traverses it mesially. At the anterior extremity of this line, between the two middle incisors of the upper jaw, is a small tubercle which corresponds to the inferior orifice of the anterior palatine canal.

The *bony portion of the palate* is formed by the upper alveolar arch, the inferior surface of the palatine processes of the superior maxillary bones, and the horizontal portions of the palate bones. On the vault of the palate the mucous membrane is denser, thicker, and less red than in the upper parts of the mouth.

At its anterior part it presents transverse rugosities, varying in number and extent; elsewhere it is smooth, and presents the orifices of mucous follicles, situated between it and the bony arch of the palate, which become more numerous near *the velum.* The gums are formed of a firm and compact reddish tissue, covering the two sides of each alveolar arch, and filling the intervals which remain between the teeth, the necks of which they closely surround. They appear composed of two layers, a pulpy and a fibrous, covered by the mucous membrane, united to the periosteum. The mucous membrane, which enters into their constitution, is prolonged into the aveoli, and from the bottom of these cavities sends into the cavity of each of the teeth, a bulbous prolongation which exactly fills it, and which has been named the *pulp or nucleus* of the teeth. The arteries of the palate and gums come from the palatine, alveolar, infra-orbitar, facial, and buccal branches, and, for the lower gums in particular, from the

sub-mental and mental vessels. The veins correspond to the arteries. The nerves are furnished by the palatine, facial, infra-orbitar, superior and inferior dentar nerves, and by the naso-palatine ganglion.

The *velum palati* is a soft, broad, thick, mobile partition, appended to the extremity of the vault of the palate, and separating the mouth from the pharynx. Its form is nearly quadrilateral. Its two surfaces, the *anterior* and *posterior* are smooth.

Its *upper edge* is very thick, and fixed to the vault of the palate; the *lower edge* is free, and floating above the base of the tongue. (*l.* Pl. 1 and 2).

It presents, at its middle part, an appendage, or prolongation, named the *uvula*. The *uvula* is cone-shaped, forming the inferior edge of the velum palati into a double arch, terminated on each side by two pillars, which are continuous with the tongue and the pharynx. These pillars are placed the one before the other, and separated by a triangular space, in which are lodged the tonsils; they are united above, but diverge below. The anterior is oblique, and contains in its substance the constrictor isthmi faucium muscle. The posterior is nearly vertical, and formed by a portion of the palato-pharyngeous muscle, internally.

The mucous layer of the velum palati (pendulous palate) contains the muscular layer, and is continued anteriorly into the membrane of the mouth, and posteriorly into that of the nasal fossæ, so that the palatine and pituitary membranes unite upon the free edge of the velum palati. The anterior lamina of this layer is less red than the

posterior, and covers many mucous follicles, extending over the free part of the muscles; they are so close as to be in contact with each other; they form, of themselves, nearly the whole thickness of the uvula; they are rounded and compressed. Beneath the velum pendulum palati, is the aperture leading from the mouth to the pharynx, the form and limits of which I have already described; its size is, in no case, equal to that of the anterior aperture; it varies, however, but only from above downwards, for on the sides it is limited by the pterygoid processes, which, of course, are perfectly fixed.

V.—Stomach and Intestines (Pl. 1 and 2).—*Peritoneum.*

The peritoneum, or serous membrane of the abdomen, is a shut sac in the male; two openings enter into it in the female. It is thin and translucid, has a very complicated course, invests the inner surface of the walls of the abdomen, forms several more or less marked folds in that cavity, and is prolonged, under the form of an envelope, over most of the viscera, which are contained in the abdomen and pelvis, and which belong to the organs of digestion, of secretion, and reproduction. It is not unusual to call that part of the peritoneum lining the walls of the abdomen its *parietal* portion, and that investing the *viscera* its *visceral* portion, but the distinction is not very practical, and of but little importance. The omenta are processes of the peritoneum.

The stomach (ventriculus, *e*, Pl. 1 and Pl. 2) is a conical, elongated, musculo-membranous reservoir, curved

from before backwards, and from below upwards, in the direction of its length, slightly depressed on its two opposite sides, continuous, on the one hand, with the œsophagus (*c*, Pl. 2); on the other, with the duodenum (*p*, *y*, Pl. 1, marks the commencement of the duodenum, or first portion of the small intestines), situated beneath the diaphragm, between the liver and the spleen, behind the left external ribs, occupying, at the upper part of the abdomen, the epigastrium, and a portion of the left hypochondrium. The greatest diameter is transverse; the smallest diameter is vertical, gradually diminishing in proceeding from the œsophagus towards the duodenum. Its two orifices are considerably contracted, and are directed upwards and backwards. Its direction is nearly transverse, inclined slightly downwards, to the right and forwards, so that its right extremity is anterior and inferior to the left. When the viscus is filled with food, this obliquity is increased, and the stomach approaches the vertical direction.

There are distinguished in the stomach—1. an external, or outer surface (*e*, Pl. 1); 2. two curvatures; 3. two extremities, each having an orifice, a larger to the left, and a smaller to the right; and lastly, an internal mucous surface (*e*, Pl. 2).

The cardia (cardiac, left, or œsophageal extremity and orifice, *c*, Pl. 1 and 2) separates the two curvatures on the left side, and is placed beneath the diaphragm, and above the large extremity of the stomach, at the union of the two right thirds and the left third of that viscus. It is in it that the œsophagus terminates. It is surrounded by a circle formed by the coronary artery and vein, and by

the extremities of the œsophageal cords of the pneumogastric nerves. It is also in relation with a part of the left lobe and lobulus spigelii of the liver (*f*, Pl. 1), and with the corresponding anterior side of the vertebral column.

The pylorus (*p, y*, Pl. 2), *pyloric, right, or intestinal extremity and orifice*, is situated in the epigastrium, lower and more anteriorly than the cardiac orifice; it terminates the stomach to the right, forming the summit of the cone represented by that viscus, and makes it communicate with the duodenum, or first portion of the small intestine. Placed in the direction of the two curves at once, it commences by a funnel-shaped expansion, and terminates abruptly by a circular contraction. It generally ascends backwards and a little to the right, as far as the union of the two fissures of the liver. It corresponds, above and before, to the liver, below and behind to the pancreas, posteriorly directly to the right gastro-epiptloic artery, and on the right side to the neck of the gall-bladder. It is often coloured by the transudation of the bile, through the walls of that reservoir, and surrounded by a number of vascular twigs and nervous filaments.

The internal (mucous) surface of the stomach (*e*, Pl. 2) is of a reddish-white colour, having a marbled appearance; it is lined by mucous membrane, and numerous and irregular wrinkles are observed upon it in its empty condition. The walls of the stomach are formed by three superimposed membranes—a serous, a muscular, and a mucous. There also enter into their composition cellular tissue, vessels, and nerves.

The *serous membrane or coat* is formed by the peritoneum, and does not exist along the curvatures when the stomach is empty, as has been already said. There results from this disposition, that the stomach in the state of vacuity is no longer covered by the same portions of peritoneum which were in connection with it during its distention, for it is then prolonged between the laminæ of the omenta. Its peritoneal tunic is white, transparent, smooth, and lubricated externally by a serous fluid; united to the muscular membrane by a cellular tissue, loose on the edges of the stomach, but dense in the middle part of its two surfaces, where there is an intimate adhesion.

The *muscular membrane or coat* is thin, and differs essentially, in this respect, from the muscular coat of the pharynx and œsophagus. It is composed of fasciculi of soft whitish fibres, never red, placed beside each other, and running in three different directions.

The *mucous membrane or coat* is soft, spongy, of a reddish-white colour, having a marbled appearance, continually moistened with an abundant inodorous viscid fluid; it presents numerous and purely accidental irregular wrinkles when the stomach is empty. When examined with a lens, especially at some distance from the orifices, it is found to be perforated with a multitude of holes disposed pretty regularly in quincuncial order, not more than a fifth of a line in diameter, separated from one another by partitions, and thus constituting a kind of reticular warp, the tissue of which recurs between the folds of the mucous membrane of the duodenum, and around Peyer's glands or follicles. It does not at first sight appear to be a con-

tinuation of the inner membrane of the œsophagus, there being an apparent line of demarcation perceived between the two membranes, caused by the seemingly abrupt termination of the epithelium or epidermis of the mucous membrane of the œsophagus. Microscopic observers, however, are now generally agreed that a fine epithelium invests the interior of the stomach at all points. The reticular surface just described has been long known. By the application of higher glasses it would appear that this appearance is connected with little depressions or cells of a polygonal figure; at the bottom of these cells or pits there are appearances of a number of minute tubes opening upon the surface of the stomach. If such tubes exist, they represent, on a small scale, the distinctly visible layer of tubes perpendicular to the cellular tunic they rest on, described by me in 1821—22 in the stomach of the cetacea, and more especially of the porpoise. This layer had been noticed by Camper and Cuvier; but the latter anatomist considered the layer as muscular. Dr. Brewster, who examined this tubular structure at my request confirmed the view I had adopted respecting the nature of this layer.* The use of this layer has not been determined; it is probably a secreting organ. The longitudinal folds which shut off the œsophageal forms terminate at the cardia by so many mammillæ or tubercles. The mucous membrane of the stomach is thicker than that of the œsophagus, neither having villosities. Between the muscular and mucous coats of the stomach, and along the two cur-

* See Transactions of the Royal Society of Edinburgh.

vatures only, are observed mucous follicles of small size, opening on the inside of the viscus by sunk, and not very apparent orifices. They are commonly called Brunner's glands, from the name of an anatomist who first described them.

At the place where the pylorus (Pl. 1 and 2) presents the least width, there occurs internally a circular rim, flattened and perpendicular to the walls of the orifice; it has been improperly called the *valve of the pylorus*; it is merely a replication of the muscular and mucous coats of the stomach, corresponding by one of its surfaces to the cavity of that viscus, and by the other to that of the duodenum, the small circumference of which is thin, free, and floating, so as to circumscribe a narrow aperture by which the contents of the stomach pass into the intestines. But its great circumference is formed by a particular fibrous ring, of a solid texture and white colour, placed between the two forementioned membranes. This ring is the pyloric muscle of some authors.

The arteries of the stomach are numerous and large, compared with the volume of the organ and the thickness of its walls. The lymphatic vessels of the stomach arise from its inner and outer surfaces, and present, for the most part their principal trunks under the peritoneum; they may be referred to three orders; they go particularly to the glands placed along the two curvatures. The nerves of the stomach come from the pneumo-gastric nerves (nervus vagus: middle division of the eighth pair of cranial nerves), and from the three divisions of the cœliac plexus, that is from the sympathetic system of nerves.

2. The *duodenum* (ventriculus succenturiatus), (*l*, Pl. 2), immediately succeeds to the stomach. It is less voluminous than that organ, but has a greater diameter than the small intestine, properly so called, and is susceptible of great dilatation. It occupies the deep middle part of the abdomen, where it is concealed by the transverse meso-colon or by the stomach, (Pl. 2, shews the whole course of the duodenum). The direction of the duodenum is such that it may be divided into three portions.

3. *The smaller Intestine.*—The small intestine (intestinum tenue), (Pl. 2, and Pl. 1, *i*, *i*), in which the duodenum terminates, is the longest portion of the digestive canal. It forms a general great curve, of which the concavity is connected with the mesentery (*a*, *c*, *m*, are placed on the mesentery, Pl. 2), while the convexity is free and floating; and it is moreover folded upon itself in different directions a great number of times, producing the *convolutions*. All those convolutions of which the convexity is directed forwards, and whose concavity faces backwards towards the vertebral column, are placed close together, and constitute a considerable mass, occupying in the abdomen, the umbilical and hypogastric regions, a portion of the lumbar and iliac regions, as well as of the excavation of the pelvis.

This mass is circumscribed on all sides by the large intestines, (an arrangement perfectly displayed in Pl. 1), that is to say, superiorly by the transverse meso-colon, (*c*, *t*), and arch of the colon, which separate it from the stomach, the pancreas, the liver, and the spleen; to the right by the cœcum (*c*, *œ*), and ascending colon, to the

left by the descending colon (*c, d*), and sigmoid flexure. The small intestine commences under the superior mesenteric vessels, on the left side of the transverse meso-colon, and terminates in the right iliac region opening into the large intestine. There results from this that its general direction is inclined from above downwards, and from left to right. Its length is about four times the length of body: anatomists have divided it into two portions, although they have failed to assign fixed and distinct limits to each of them. The upper is named *jejunum*, on account of its being commonly found empty; the other is called the *ilium*.

The jejunum occupies the two upper fifths of the small intestine, and the ilium the rest of its extent. The division is arbitrary, and has no sufficient foundation. A projection called a *diverticulum*, composed of the same tunics as the intestine, and communicating with it, is occasionally found upon the small intestine; it has been supposed by Mr. Meckel to be the remains of the vesicula umbilicalis of the fœtus, and by its presence marks a distinction in the canal above, and below it. I concur in this opinion.

The small intestine has a smaller calibre than that of the other parts of the digestive canal; it is wider above than below. Its *outer surface* (Pl. 1, *i*), is smooth, excepting on its posterior edge, where it is destitute of peritoneum, and lodged between the two laminæ of the mesentery; its *inner surface* (Pl. 2), has the same appearance as the duodenum. There are seen upon it numerous villosities, disposed in the form of more or less prominent

fringes, and extremely large valvulæ conniventes.* But the latter are more numerous the nearer to the duodenum the intestine is, and diminish progressively towards the cœcum.

4. *The large Intestines,* intestinum crassium, (*ct, c, i, d, c, œ,* Pl. 1, and Fig. 2, Pl. 7).—The small intestine, after diminishing in calibre, enters the large intestine upon its left side; the peritoneal tunic binds down this gut in a remarkable way to the large intestine, and it is this chiefly which gives rise to a valve (ileo-colic and ileo-cœcal valve), to be afterwards described.

The appendix vermiformis (a small prolongation of the cœcum downwards), is similar to the rest of the cœcum in its structure; its fleshy coat is thick and formed of longitudinal fibres. Three bands of the intestine (these bands are well seen in Pl. 1), seem to come from it, of which we shall speak presently; it communicates with the cœcum by an orifice which allows air readily to enter, but not to escape so easily. The mucous membrane, at its orifice, forms a sort of valvule. The appendix is sometimes wanting. The cœcum (*c, œ,* Pl. 1, and Fig. 2, Pl. 7, *c, œ*), is placed between the end of the appendix vermiformis and the colon in the right iliac fossa. Its volume is often triple that of the small intestine, and surpasses that of the colon or rectum. Its length is about three or four finger breadths, and no other limits can be assigned to it, to

* Valvulæ conniventes: folds of the mucous membrane of the small intestine, projecting into the interior of the tube; they are transverse in man, but longitudinal in some of the lower animals, as in reptiles.

distinguish it from the colon, than the termination of the small intestine.

5. *Of the Pancreas,* (Pl. 1, *p,* the first layer requires to be reversed).

The pancreas, though situated in the abdomen, is now generally admitted to be analogous to the salivary glands already described.

It is of a greyish-white colour, inclining to red, of a rather irregular form, and has no special capsule enclosing it. It lies across the vertebral column, and is curved naturally to meet this position, although it be usual to describe it as straight, an error arising, no doubt, from its having been generally described and drawn after having been removed from the body.

It is situated between the three curvatures of the duodenum, behind the stomach, and to the right of the spleen which it approaches by its left extremity. The superior mesenteric artery and vein pass under its lower edge at the part where the organ is narrowest. The parenchyma or glandular part of the organ is firm, and appears composed of lobes and granular bodies connected together by cellular substance. From these granulations and lobules proceed the small ducts, which, uniting in the manner of veins, form at last the duct of Warsung.

This duct (*d,* Pl. 1), may be traced from near the tail of the gland until it passes into the second portion of the duodenum. It is usually simple, but other smaller ducts

often run parallel to it; it is said to be in the fœtus uniformly double.

Placed in the substance of the organ, a little nearer its lower than its upper margin, directed from left to right, and progressively increasing in size from the numerous branches it receives in its course, the duct proceeds in a serpentine course towards the duodenum; quits the gland and becomes free behind the second portion of the duodenum. As it is about to enter the gut it receives the duct of the smaller pancreas. It soon adheres to the ductus communis cholidochus (common duct of the bile), with which it unites; or it enters the duodenum apart and simply: sometimes near the ductus cholidochus, sometimes considerably removed.

The pancreas, beside resembling the salivary glands in many other particulars, resembles them also in this, that it has no special artery sent to it from the aorta, but it is supplied from several sources.

Its nerves are from the sympathetic. It is not often found the seat of disease.

6. *The Spleen,* (Pl. 1, attached to the large extremity of the stomach).

The spleen is a solid vascular organ, situated in the left hypochondrium, beneath the diaphragm, above the descending colon (*c, d*), and between the cardiac extremity of the stomach, and the cartilages of the false ribs, before the left supra-renal capsule and kidney. The posterior portion of the inner surface is applied to the

left side of the vertebral column. Folds of the peritoneum attach it to the surrounding organs. Its volume varies much, and having no excretory duct, its probable functions in the economy cannot be determined.

Little or nothing is known of the intimate nature of the parenchyma of this organ, and nothing whatever of its functions.

7. *Of the Liver. Hepar.* (*f,* Pl. 1).

The liver is the largest gland in the body. Besides performing, no doubt, other functions, it secretes the bile. It is a single unsymmetrical organ, dense, of a deep brown colour, and readily torn. It occupies the whole of the right hypochondrium, and a portion of the epigastric region, extending downwards for a very short way below the margins of the ribs. Its weight in the adult varies from two to five pounds.

The radicles or roots of the hepatic ducts commence in the parenchyma of the liver, and, uniting, give rise to larger branches. These at last form two trunks, one for the left lobe, the other for the right, which leave the substance of the liver, and pass into the transverse sulcus; these uniting form the hepatic duct. The duct is about one and a half inch in length, and about a line and a half in diameter. It has two tunics, an inner mucous, and an outer fibrous, and, perhaps, muscular. It unites at length with the cystic duct at an acute angle, thus forming the ductus communis cholidochus. The common duct thus formed, descends behind the second portion of the duode-

num, (*d*, Pl. 1, reverse side), through the coats of which it passes obliquely, entering the bowel at a variable distance from the pylorus, but usually along with the duct of the pancreas, at the end of the second portion of the duodenum. It is from three to three and a half inches long; its fibrous tunic is distinctly muscular; the fibres run obliquely and longitudinally; its duodenal opening is provided with a membranous fold or semi-valve of the mucous membrane of the intestine; its mucous tunic is continuous with that of the intestine and gall bladder.

Of the Gall Bladder and Cystic Duct, (*v*, *b*, Pl. 1).

The gall bladder is a membranous pyroform reservoir for a certain amount of bile which passes into it, and returns to the cystic duct, there being no hepato-cystic duct in man. It is fixed in a hollow, excavated on the concave side of the liver, between the great lobe and the lobulus quadratus (square shaped lobe), which it separates. The peritoneum passes over it, giving it a partial covering, which of course is deficient over all that portion of the gall bladder which is more immediately in contact with the liver. The descriptive anatomist divides the gall bladder into a body, a fundus, and a cervix or neck. The fundus is rounded, and entirely covered by the peritoneum, and passes beyond the sharp-edge of the liver; the body adheres to the liver by cellular substance and blood-vessels. The cervix or neck is continued with the cystic duct.

Tunics.—Besides the peritoneal, the gall bladder has, 1st. a cellulo-fibrous; and, 2nd, a mucous coat. The cellulo-fibrous presents nothing remarkable in its structure. The mucous is rough, reticulated, and silicate. In the vicinity of the neck of the gall bladder, and, especially, in the cystic duct, there are five or six imperfect valves; they allow a probe, or air, to pass readily into the gall bladder from the cystic duct, but impede their return from the bladder to the duct. Its arteries arise from the hepatic, its nerves from the *hepatic* plexus. Whilst enclosed in the smaller omentum, and surrounded by the capsule of Glisson, the ductus communis cholidochus is situated to the right, the hepatic artery to the left, and the vena portæ between and behind these vessels.

Structure of the Liver.

The proper substance of the liver or the parenchyma, is compact but not firm; hence its liability to be torn during life. It seems composed of lobules varying from half a line to nearly a line in diameter. They are, in short, about the size of a pin's head, connected to each other by fine cellular tissue and by the blood-vessels. But even here observers do not agree; some imagining the lobules to be isolated, others viewing them as connected or continuous at various points. I lean to the opinion, merely from analogy however, that they are essentially isolated. Each lobule is said to rest by a smooth surface or base upon a branch of the hepatic vein, connected with it by a small venous trunk which arises in the centre of the

lobule, and passes out from the middle of its base to end in the larger subjacent vessels. To the small vein the name of intra-lobular has been given. The branch of the hepatic vein with which it communicates has been called sub-lobular.

The sub-lobular veins so formed unite into larger and larger vessels, and at length into another kind of vessels (hepatic venous trunks) which receive intra-lobular veins. These terminate in the vena cava, on the convex and blunt edge of the liver.

The other vessels which *enter* and *leave* the liver have a totally different arrangement; they are the portal veins, the hepatic artery, and the biliary ducts.* Within the liver branches of these vessels lie together in canals, called *portal;* these commence at the transverse fissure and branch upwards in all directions. Glisson's capsule enters with them and encloses them. A transverse section of one of these portal canals proves this, shewing the open orifices of a branch of the portal vein, hepatic artery, and biliary duct, enclosed together by a cellular sheath. The ultimate branches of the portal vein proceed to ramify on the lobules; from the net-work which these form in the lobules, the inter-lobular vein, that is, the commencement of the hepatic veins, takes its origin.

* The words porta and portal are much used with reference to the liver. The term porta means entrance, and the vessels entering the part of the liver called porta are hence called portal, which, however, is chiefly applicable to the remarkable vein, called vena portæ, which, after collecting the blood from the tract of the intestines, enters the liver by the porta, and is distributed through the organ in the manner of an artery.

The hepatic artery also gives off vaginal and interlobular branches. These are distributed to the coats of the various vessels, especially to the ducts, capsule of Glisson, cellular tissue, and proper tunic of the liver. Beyond all this is conjecture, for the mode of termination of the hepatic artery, and its connection with the other system of vessels, has not been demonstrated.

The hepatic ducts, after leaving the lobules, collect in the portal canals, to reunite in the ductus hepaticus.

The biliary ducts at their commencement contain a peculiar substance, supposed to be composed of numerous nucleated corpuscules. On them probably depends the secretion of the bile.

The hepatic cells just adverted to are said to measure from $\frac{1}{840}$ to $\frac{1}{1000}$ of an inch; they may contain one or more nuclei, and are slightly yellow. They lie in rows amongst the vessels.

Development.—The liver begins to be formed very early in fœtal life. At the third or fourth week, the liver is said to form nearly one half the weight of the whole body. This ratio gradually decreases as development advances; at birth it is as 1 to 18. At first the right and left lobes are nearly of equal size; the position is more symmetrical, and it occupies a large portion of the cavity of the abdomen.

8. *Supra-Renal Capsules.*

These are two small organs placed above the kidneys, the upper extremities of which they embrace. Their uses

are wholly unknown, nor is much known of their intimate structure beyond the mechanical tracing of arteries carrying red blood to them, and veins returning venous blood from them to the venous system ; yet they are never absent, and are very large in the fœtus. It is this circumstance which has induced physiologists to view them as being, in some way or other, subservient to fœtal life.

9. *The Kidneys,* (Renes, hence renal, &c.) (Pl. 2d, 3d, and 4th, *r*).

They are situated in the lumbar region, on the sides of the vertebral column, opposite to the last two dorsal, and the first two lumbar vertebræ—one to the right, the other to the left—and are enveloped on all sides by a thick mass of fat; the left is higher than the right, and generally larger ; in the male the average weight is from four and a half to six ounces, and in the female from four to five and a half.

Their colour is a dark red, inclining to brown, and their form that of a kidney bean.

The renal arteries are large, and generally single; but sometimes there are two or more to each kidney; they arise from the aorta. The renal veins which are also large, join the vena cava inferior, the left is the longest, having to cross the spine. A nervous plexus accompanies these vessels, derived from the semi-lunar ganglion, and solar plexus of the sympathetic; a plexus of lymphatic vessels also exists. The parenchyma of the kidneys is firmer than that of the other glands; it is composed of two distinct

substances, an external or *cortical*, and an internal or mammillary, also called tubular.

When the kidney is destroyed by disease, the remaining one, if sound, enlarges, becomes more vascular, and performs the duties of both.

VI.—Organs of Digestion, etc.—Physiology. (Pl. 7, Figs. 3, 4, 5).

1. The form and size of the lips, mouth, tongue, &c., vary in different races of men; the two extremes are the Australian and Bosjieman on the one hand, and the finely formed mouth of the European as represented in the matchless antique marbles. These circumstances greatly influence the expression of the face, but it is probable that they do not exercise over the speech that influence which might at first be supposed. Much depends on education and imitation: the parrot with anatomical structures so opposite to man, imitates his speech and voice perfectly.

The Teeth. Their Physiology.

The functions of the teeth are mechanical, and in civilized society, where the greater part of the food is subjected to a more or less refined cookery, the molar teeth are not used to the same extent as by savage nations. It is probably owing to this that in many savage races the molar and other teeth are worn down until they assume the form of flat surfaces; in other words their tuberculated surfaces disappear. The opinion prevails that most disorders of the teeth begin in the enamel.

In mastication (Figs. 2 and 4, Pl. 5), the temporal, masseter and pterygoid muscles make use of the immovable skull as their fixed point.

2. In deglutition (Pl. 1 and 2), the food and drink urged backwards by the tongue and cheeks passes through the isthmus of the fauces and enters the pharynx, (Pl. 1 and 2); it is now grasped by the muscular walls of this cavity and forced into the gullet, (*œ*, Pl. 1), which being also muscular urges it onwards until it reaches the stomach, (*e*). It will be readily understood that gravitation can have but little to do with the process of deglutition. When the head is thrown well backwards the passage from the mouth to the interior of the stomach is nearly straight.

The mechanism of the palate has been already explained and likewise the functions of the epiglottis, (Pl. 1 and 2); it remains only that we should consider the function of the salivation.

3. The uses of the saliva are but imperfectly understood, and why so many glands should be concerned in this function. Of the anatomy of these glands we have already spoken; they are the sublingual, submaxillary and parotid. The fluid of the mouth called the saliva consists in reality of an admixture of different secretions, derived not merely from the salivary glands, properly so called, but likewise from the labial and buccal glands from those of the gums, tongue and palate. Thus the qualities of the saliva vary according to a variety of circumstances. Healthy saliva has an alkaline reaction, and contributes, no doubt to the chemical solution of the food. The pan-

creatic juice which formerly was considered identical with the saliva, is now generally admitted to possess peculiar properties.

4. *Digestion in the Stomach.* (For the mucous surface see Pl. 2).—It is in this cavity that the food is converted into chyme. Besides being acted on by the muscular walls of the organ, propelling it onwards towards the pyloric orifice of the cavity through which it is to pass into the duodenum, the food is rotated in the stomach, and is exposed to the action of the gastric juice secreted by the gastric glands, clusters of which may readily be recognized by a low magnifying power in proper sections of the inner or mucous membrane, (Pl. 2).

The empty stomach (Pl. 2) contains a mucus which has a neutral or faintly acid reaction. If this be scraped off, we come upon a fluid below it which strongly reddens vegetable colours. If the membrane be irritated in a living animal, the quantity of this secretion is increased and the secretion becomes decidedly acid. The presence of food gives rise to the same results. The nature of this acid has been much disputed. At one time it was thought to be the hydrochloric, or the lactic: this latter opinion is the more probable one.

The quality of the chyme which passes immediately into the duodenum, (Pl. 1, p. 7), must evidently vary with the different nature of the food. It generally constitutes a mechanical mixture of a grey gelatinous semi-transparent mass with all those relics which have resisted the action of the gastric digestion. The mechanical mixture may consist of raw starch granules; decolorized simple, dense or

woody cells, and bundles of vessels; fat; pulverulent relics of hard albumen or casein; fragments of cartilages; muscular fibres; tendons; ligaments; splinters of bone; or salts of the osseous tissue.

The mucous membrane of the stomach (Pl. 2, *c*), appears to be one of the most sensitive parts of the body, but notwithstanding the numerous enquiries which have been made into its nature and functions, the subject of digestion and indigestion are still extremely obscure.

5. *Function of the Intestines and of their glandular appendages. The Liver, Spleen, and Pancreas.* (Pl. 1 and 2).—The residue of the food which passes into the small intestines next encounters the intestinal juices; that is the different secretions furnished by the various glands already enumerated. In the duodenum they meet with the pancreatic fluid and the bile. The precise nature of the secretions furnished by the smaller or mucous glands has not been determined; the pancreatic juice varies under a variety of circumstances. It seems to aid in the conversion of fluid fat into the form of an emulsion. (Pl. 1, *p, d,* seen on the reverse of the first layer of the engraving). One thing is certain, the pathological alterations of the pancreas deeply affect the nutrition of the body. In the large intestines, the food undergoes further changes and becomes more and more excrementitial.

6. The liver secretes the bile. The numerous attempts of chemists to investigate the constituents of the bile have not hitherto led to any satisfactory physiological results, (Pl. 1, *f.*) In the chapter on the secretions I shall describe at greater length the various characters of the bile, pan-

creatic fluid, etc.; here they are simply alluded to as secretions obviously connected with the digestion of the food. This is a question of much difficulty, and as regards the bile, has been answered in a variety of ways; the bile, no doubt, separates from the blood certain substances previously useless; but in this light these must be viewed as excretions. A part of the substances which the bile removes from the blood is gradually rendered insoluble, and discharged as excrementitious; but those compounds which retain their liquid form, and perhaps many which are gradually redissolved, are returned anew into the blood."

Fresh bile is usually either neutral or at most but faintly alkalescent.

Jaundice proves that the bile plays some important part in the phenomena of digestion and in the formation of chyle, that fluid, out of which the blood is formed, and on which depends the nourishment of the body. It is formed in the small intestines from which the lacteals arise. The residue of the food, and of various secretions not reabsorbed is finally collected into the large intestines from which it is at last discharged. (Pl. 1, *cœ, et, c, d.*)

The chyle thus formed is a milky opaque fluid, which was first, no doubt, detected in the lacteals, the vessels intended to absorb it from the mucous surface of the intestine, and to convey it to the general torrent of the blood with which it mingles. The history of the organs which effect this will form the subject of the next chapter.

CHAPTER III.

ORGANS OF ABSORPTION OF THE CHYLE AND LYMPH, USUALLY CALLED THE ABSORBENT OR LYMPHATIC SYSTEM OF VESSELS.

Anatomy and Physiology.

(Pl. 1, *c, t,* thoracic canal, *r, p,* receptacle of the chyle. Pl. 2, deepest layer).

Prior to the discovery of the lacteals, lymphatics and their glands, the veins were considered as the only absorbing vessels. The Hunters, William and John, and the school they gave rise to, discarded the veins altogether from their office of absorbing vessels, bestowing this function wholly and exclusively on the lymphatics, or absorbent vessels properly so called. Lately, physiologists have made efforts to restore at least a portion of the office to the veins.

But be this as it may, it is undoubted that to this system of vessels belongs mainly the function of absorbing: 1st. By means of the lacteals, the fluid called chyle, the product of digestion; as this fluid resembles milk, at least in colour and general appearance, the vessels conveying it from the intestinal tube have been called lacteals. 2nd. Of taking up or absorbing from nearly all the tissues of the body a fluid called lymph; hence the name lymphatics, or carriers of lymph.

These two sets of vessels strongly resemble each other anatomically, though differing probably physiologically. The lacteals arise from the mucous membrane of the small intestines, and their mode of origin has not been clearly made out; but one thing is certain, they proceed in great numbers to pass through certain bodies called lacteal glands, (mesenteric, as being placed in the mesentery), on leaving which they terminate in the thoracic duct, the termination of which is near the junction of the left subclavian and left jugular veins. Thus the chyle is poured into the veins, where it mingles with the venous blood. But it is into the thoracic duct, (*c, t*, Pl. 2), that by far the greater part of the common lymphatics or absorbents, arising in all the textures of the body, also pour their contents. The fluid circulating or flowing in the thoracic duct is then of a mixed character, and, at least after digestion, must be held to be composed of two opposite and distinct substances; that, namely, which is proceeding towards the heart to restore the losses of the body, and that refuse portion of the organs which has already served the purposes of nutrition.

As this system of vessels was discovered by piecemeal or fragments, so is it usually investigated by the student. One portion of it he sees at one time, and during one dissection, another at another. He never attempts, nor is it incumbent on him to do so, to dissect the absorbent system systematically and continuously; but it is right that a systematic description of the system be placed before him. This is the object of the present brief chapter.

Whilst proceeding to the glands they are called *vasa*

*inferentia;** when leaving them for the thoracic duct they are denominated *vasa efferentia;* but they are presumed to be the same vessels.

By the same method† the lymphatics may be shown in any other part of the body. They may be readily found in the subcutaneous cellular tissue, &c.

The lymphatic or absorbent system, then, is composed of vessels and glands, or, at least, of bodies which are called so. The vessels are long, extremely delicate, and almost pellucid tubes, presenting when full, at short intervals, dilatations, giving to them a knotted appearance. This is due to the presence of valves, placed in the interior of these tubes, whose arrangement and functions altogether resemble what has been shown to prevail in the veins.

As a necessary result of the presence and strength of these valves, the lymph and chyle can only flow in one direction—that is, from branch to trunk; hence the difficulty of their dissection and injection. How they act on their contents is not known, but the fact is certain.

The absorbents are extremely numerous, and have been demonstrated in most organs of the body; their presence, however, in the brain, spinal cord, their membranous envelopes, the eye and ear, has not been satisfactorily demonstrated.

These vessels are arranged in two distinct planes, a superficial and deep-seated. The *superficial* are found on the periphery of the body, in the subcutaneous cellular

* Inferentia, as carrying the chyle to the glands; efferentia, as carrying the chyle from the glands.

† By injecting quicksilver into them.

tissue; the *deep-seated,* arising also in the cellular tissue, collect in bundles around the great blood-vessels, whose direction they follow; but these two planes unite freely, and form plexuses. Occasionally, a great number of twigs collect into a single trunk; this trunk again subdivides, and afterwards re-unites.

The largest, but not the only terminating trunk of the whole system, is the thoracic duct (*c, t,* Pl. 2, and Pl. 1), a vessel already described in the anatomy of the thorax (see the explanation of Pl. 2). In this trunk terminate, directly or indirectly—1st. The lymphatics of the lower extremities. 2nd. Those of the abdomen, including the lacteals (Pl. 2). 3rd. Those of the left side of the thorax and left upper extremity. 4th. Those of the left side of the head and neck.

The lymphatics of the right side of the head and neck, right upper extremity, and right side of the thorax, terminate in a short trunk situated on the right side of the superior dorsal vertebræ. This trunk joins the venous system at the junction of the right subclavian and right jugular veins.

The *lymphatic conglobate glands* occur in the course of these vessels. Through these glands the vessels pass, seemingly uninterruptedly—that is, without losing their character of vessels. Nothing is known of the functions of these glands. They vary in diameter from the twentieth part of an inch to an inch. Their colour is reddish, changing to grey, and they are enveloped by a compact capsule of cellular tissue. Though occasionally isolated, they are more generally collected into groups, and abound in the abdomen.

The groups of mesenteric glands may amount to a hundred; they abound, also, around the vena portæ, splenic artery, aorta, between the laminæ of the mesocolon* (mesocolic), along the two curvatures of the stomach (gastro-epiploic†). A variable number may be seen in front of the lumbar vertebræ; others in the line of the iliac vessels. Lastly, they abound in the groins, the axillæ, and the neck.

The names given them are generally derived from their position, as cranial, cervical, sacral, hypo-gastric, inguinal, deep, or superficial.

In the neck, the superficial are found chiefly below the platysma myoides;‡ the deep-seated (glandulæ concatenatæ), near the internal jugular vein and carotid artery. They here form a chain, extending from the mastoid process to the superior orifice of the thorax, prolonged backwards between the pharynx and vertebral column.

In the superior extremity, the lymphatic glands (as do the vessels) follow closely the line of the great blood-vessels, from the elbow to the axilla. A lymphatic gland is generally found immediately above the inner condyle of the humerus; in the axilla, they abound, and are of great size.

In the inferior extremities, one of the glands we now describe is very uniformly found on the lower extremity of

* Mesocolon: a part of the peritoneum, or great serous membrane of the abdomen, supporting the colon.

† Gastro-epiploic: what is connected both with the stomach and the epiploons, or cauls.

‡ Platysma myoides: the superficial muscle of the neck.

the interosseous ligament; it has been called anterior tibial. In the popliteal space, where they are called popliteal, they are somewhat numerous, but small; in the inguinal region (inguinal glands), they are large and numerous, and have been divided into two layers, a superficial and deep. The superficial, varying from six to twelve in number, surround the saphena vein, imbedded chiefly in the cribriform fascia.* The deep inguinal, four or five in number, embrace chiefly the femoral artery.

Although I have examined the thoracic duct very carefully many hundreds of times, I have never found it in any way injured, or diseased, nor have its contents presented anything remarkable. Twice I have seen the gastro-epiploic lymphatics filled with a matter resembling scrofulous purulent fluid; in these cases, the conglobate glands were filled with the same matter. The lymphatic glands throughout the body are liable to constitutional disease. Though slow to inflame, inflammation of the lymphatics, when it does occur, is extremely rapid and fatal, as exemplified by puerperal fever and by poisoned wounds of the fingers, occurring in dissection. When inflamed, they enlarge to a great size, and become filled with pus. The functions of the system are, upon the whole, but little understood.

The lymphatic and lacteal vessels of the stomach and intestines are important. They may be subdivided into two sets: 1. lacteals, properly so called; 2. common absorbents. I believe these vessels to be physiologically distinct.

* Cribriform: that is, full of holes.

1. The lacteals (*u, c, m,* Pl. 2, *v, c,* Fig. 4, Pl. 4) are readily found on carefully inspecting the mesentery, and cautiously removing one of its layers. They are very numerous. I have already spoken of these vessels. They are found only in the mesentery,* and are the more numerous the higher up they are examined. The functions of these vessels have been tolerably well made out; but this cannot be said of those lymphatics which arise from the mucous membrane of the stomach and of the large intestine.

The fluids they contain have not been analysed. Numerous lymphatics arise from the cellular surface of the peritoneum; others from the spleen, pancreas, and liver. But, however originating, they all terminate, directly or indirectly, after having passed through various absorbent glands, in the thoracic duct.

Ductus thoracicus sinister (*c, t,* Pl. 1, *c, t,* Pl. 2).—This important vessel, which, however, is not larger than a crow's quill, commences on the body of the third lumbar vertebra, by the successive union of five or six large trunks, resulting from the assemblage of nearly all the lymphatic vessels and plexuses I have just enumerated.

At its commencement, the duct generally presents a dilatation (receptaculum chyli,† *r, p,* Pl. 1), which generally passes behind the aorta, at the anterior and left part

* Mesentery: the portion of the peritoneum supporting the small intestines.

† The receptaculum is not intended solely for the reception of the chyle; all the lymph collected in the sub-diaphragmatic half of the body of necessity passes through it.

of the second lumbar vertebra. The duct, contracting, ascends into the chest, between the crura of the diaphragm, with the aorta on its left side, and the vena azygos on the right. As it ascends through the chest, imbedded in the loose cellular tissue of the posterior mediastinum,* it continues to contract as far as the sixth dorsal vertebra; after which it gradually dilates, ascends behind the aorta to the left subclavian artery, on the inner side of which it is placed, resting on the longus colli muscle. It then reaches the seventh cervical vertebra, bends inwards and downwards, passes behind the left thyroid artery and internal jugular vein, and here enters the left subclavian vein (Pl. 1, *c, t*, Pl. 2, *c, t*).

Two valves are found at its entrance into the vein, the functions of which may be to prevent the blood circulating in the vein passing into the duct.

The course of the duct through the chest (Pl. 1 and 2) is commonly straight, but sometimes flexuous; and in some cases it has been observed to divide into branches, which were again re-united before it reached the subclavian vein.

The lymphatics of the lungs and heart are superficial and deep. They pass through the bronchial glands, from which different vessels proceed to the right or imperfect thoracic duct; but the greater number join the left or thoracic duct, properly so called.

* Mediastinum: the term is applied equally to a cavity existing between the pleuræ and to the folds of the pleuræ, which form the cavity; but exact anatomists always speak of them as—1. the cavity of the mediastinum; 2. the walls of that cavity. They also divide the mediastinum into three cavities: an anterior, middle, and posterior mediastinum.

The general disposition of the lymphatics of the superior extremities resembles that which obtains in the lower.

The epicranial* lymphatics descend and pass through the conglobate lymphatic glands of the neck, on their way to the right and left thoracic ducts. Disease or a wound of the scalp may give rise to an enlargement of the lymphatic glands of the neck, which must not be confounded with constitutional disease, properly so called.

Some rare occasions have occurred in which the valves of the lymphatics happened to be imperfect—at least, in so far as not to perform their functions; in such cases, the absorbents could be injected from trunk to branches; but I have never met with a case of this kind.

Absorption.—Physiology of the Lacteals and General Absorbents, or Lymphatics.

The systems of vessels just described perform, to a certain extent, the same function; they both absorb. But the lacteals seem to me to absorb only chyle, whilst the common lymphatics or absorbents take up the lymph. Some modern physiologists, however, do not think this distinction of any great importance, and they affirm that, during fasting, the so called lacteals contain only lymph, and that if other lymphatics absorb fat, they also contain chyle. It has even been asserted, that the lymphatics of the large intestines may be made to absorb fatty matter, by injecting meal-broth into the bowels. However this may be, I feel assured, from many dissections of the seal,

* Epicranial: that which lies upon, above, or exterior to the cranium.

porpoise, &c., that, under ordinary circumstances, the lacteals alone absorb the chyle, and that the common lymphatics of the small intestine do not absorb chyle.

The true lacteals are limited to the small intestine; the lymphatics arise from most textures of the body. The lymph, as well as the chyle, moves more slowly in the vessels than the blood; both move constantly onwards towards the thoracic duct, by which their contents are conveyed into the system of the veins, and thus mingled with the venous blood on its way towards the heart.

Various liquids taken into the stomach pass into the blood, and thus reach the lungs. How these liquids are absorbed, we know not; neither is anything known of the manner in which the chyle and lymph are taken up by the absorbents.

Although many physiologists think that some of the lacteals open into venous branches, I still doubt the truth of this assertion.

The chyle does not pass through the liver. Normal chyle exhibits innumerable fatty molecules, but no mechanical admixture of these can be detected in the blood. The conversion of chyle into blood probably takes place in the lungs, but nothing is known of its mode of conversion.

The valves which abound in the larger lymphatic trunks are not unfrequently wanting in the very small branches, and when this happens, these vessels may be injected with quicksilver in a direction contrary to the course of the lymph. A vermicular movement never occurs in the lymphatics or lacteals, and hence the cause of the onward movement of their contents towards the veins is not well

understood. The walls of these vessels are elastic, and absorption is probably continuous. The function of the absorbent glands is unknown.

CHAPTER IV.

OF THE ORGANS WHICH CIRCULATE THE BLOOD—THE VEINS, ARTERIES, AND HEART.

Anatomy (Pl. 2, and Pl. 3).

The heart is the centre of the circulation of the blood; to it all the veins proceed, and in it—speaking physiologically, or with reference to their functions—they terminate. From the heart proceed the two great arteries from which all the others spring—namely, the pulmonary artery and the aorta; the former destined to convey the dark blood to the lungs; the latter, by its infinite subdivisions into branches, intended to convey, as in pipes or tubes, the nutrient fluid, the blood, into every part of the body. We might thus commence the description of the organs which circulate the blood with the heart itself, but it will better suit the character of this work to describe these organs in a physiological order, and thus the student never loses sight of the great principle connecting the whole series together.

I.—The Veins (Pl. 1, 2, and 3)

Commence in the minute capillary vessels* which per-

* Capillary vessels: a system of extremely small vessels, interposed

vade most of the tissues, and which, at one time, were thought wholly to constitute them. They (the veins) are supposed to be the continuation of the minute capillary arteries, and of some tissues this may be demonstrated. In whatever way they commence, they are soon found to be collecting into branches, and ultimately into trunks, or larger vessels, tending in their course towards the heart. In the limbs, they form two sets of vessels, the superficial and the deep: the superficial may readily be seen, especially in the aged, immediately under the skin, imbedded in the superficial fascia. In the arms and limbs, these superficial veins have received special names: in the former, a vein, or veins, running up the centre of the fore-arm, is called median; another, ascending on the outer side of the arm, is called cephalic; one on the inner side of the arm, has received the name of basilic; and the short veins which proceed from the median to join these, are called respectively median-cephalic and median-basilic. It is at the bend of the elbow where a vein is usually opened, when blood-letting or phlebotomy is required, and the vein which ought to be selected is the median-cephalic. The letting of blood, in this or in any other way, an operation frequently performed in my younger days, is now but rarely had recourse to.

By passing a ligature around the arm above the middle,

between the termination of the veins and the commencement of the arteries. The expression "système capillaire" was invented by Bichat, to express this important system of vessels.

sufficiently tight to arrest the course of the blood in the veins, their whole course from the extremities of the fingers soon becomes visible, and by this simple experiment, Harvey demonstrated the following important facts: 1st. that the course of the blood in the veins is towards the heart, uniformly; 2nd. that the veins, arising by small branches, proceed to terminate in larger trunks as they travel onwards towards the heart; 3rd. that the veins have valves, by means of which the blood they contain is permitted to proceed only in one direction—namely, towards the heart. The position of these valves, which dissection alone can demonstrate, is pointed out by the knots which the veins show in their course (Pl. 3, Fig. 5).

But besides these superficial veins whose position and course may be determined without dissection, there are others which anatomy alone can prove or demonstrate. These are called the deep or profound veins, or *venæ comites,* because they accompany the arteries. Each artery is usually accompanied by two veins, and the names given to these veins are derived from the arteries. Thus as regards the upper extremities, the deep veins are called ulnar, radial, brachial, &c., after the arteries. Nearly the whole of these veins at last unite in the axilla, or arm-pit, into a very large venous trunk, which on crossing the first rib on its way to the heart is called the subclavian vein.

In Plate 2, the arrangement of these subclavian veins, right and left, is exceedingly well represented; they are lettered *v, s, d,* and *v, s, g,* and are shewn at the ponit where they are receiving nearly all the venous blood

returning from the head by the internal and external jugular veins of each side. The subclavian veins, by uniting with these jugular veins, form the venæ innominatæ superiores, also two in number, (seen in the same plate), and by their union is formed the vena cava superior marked *v, c, s.* Before entering the right auricle of the heart, *o, d,* one more vein joins the vena cava superior; it is the azygos* vein, which collects the inter-costal† veins, and receives the blood they bring from the walls of the chest.

Thus is conveyed to the right auricle of the heart (*o, d,* Fig. 1, Pl. 3, and many others) all the dark blood returning from the superior extremities or arms, from the head and neck, and from the walls of the chest.

Of the veins which return the blood from the head, the great peculiarity in their arrangement is the presence of the sinuses of the dura mater already described in Section I. The brain abounds with blood vessels, arteries as well as veins; the venous blood escapes from the interior of the head by the lateral sinuses which terminate in the internal jugular veins. Another remarkable feature in the venous circulation in the head is the presence of numerous veins situated between the two tables of the skull in the substance called diploe. These veins were known to Hippocrates.

The veins of the brain have been subdivided into the superficial and deep; also into the superior and inferior, but they all or nearly all empty themselves into the sinuses.

* Azygos: that is, single, or without a yoke-fellow.

† Intercostal: between the ribs.

A curious question has been much disputed by physiologists, namely, whether there can be at any one time, more blood within the cavity of the cranium than another. Mathematicians who have been appealed to, to solve the question, think that there cannot be more blood within the head at any one time more than at another. However this may be, when the blood escapes from the blood-vessels by their rupture into the substance of the brain or spinal marrow, it causes death by apoplexy, if the quantity be considerable.

As regards the lower extremities, the arrangement of the veins is similar to what we find in the upper. There are *two* large superficial veins, called saphenæ, whose whole course may be displayed by placing a tight bandage for a short time around the upper part of the thigh; deep veins accompany the arteries, and from these are called plantur, tibial, fibular, popliteal, and, at last, femoral, as they form the large trunk which is intended to convey the greater part of the blood from the lower extremity to the trunk of the body. As this large vessel enters the trunk by passing over the horizontal ramus or branch of the pubes, it assumes the name of external iliac; in the pelvis it is joined by the internal iliac which brings to it all the blood which has circulated in the organs and fleshy walls of the pelvis. A little higher up, the external iliac veins, right and left, by uniting, form the common iliac veins, also right and left, (Pl. 2), which running together give rise to the great vein called vena cava inferior; *v, c, i,* Pl. 2, also Pl. 3, Fig. 5.

As this, the largest vein in the body, ascends through

the trunk, it is situated on the fore part of the spinal column, to the right of the aorta (see Pl. 2), and behind all the viscera. In its course upwards it receives the renal, lumbar, and other veins, but not those from the digestive organs and their appendages; these, viz. the mesenteric, gastric, splenic, &c., unite into a large trunk called vena portæ or portarum, and this proceeding to the liver, enters that organ, and redistributes its branches throughout its substance after the manner of an artery. But all the blood thus sent to the liver, as well as the residue of the blood conveyed to the same organ by the hepatic artery, is afterwards collected into two large trunks which join the vena cava inferior immediately before passing through the midriff. On receiving this last supply, the inferior cava enters the right auricle of the heart; (*o, d,* Pl. 2). All this may be most distinctly seen by raising up successively the layers composing the dissected, Pl. 2. There is also an excellent view of the course and entrance of these veins into the auricle to be seen at Fig. 5, Pl. 4, and at Fig. 5, Pl. 3. The valves of the veins are represented at Fig. 5 (*bis*), Pl. 3.

The remarkable vein called the azygos vein, that is, the vein without a fellow, is well represented in Pl. 1, on the deep layer of the engraving. It is not lettered.

Lastly, to complete this brief view of the veins which carry dark blood, we have to mention the cardiac veins, which bring back the blood from the substance of the heart itself, and carry it into the right auricle.

In Fig. 1, Pl. 3, there will be found an excellent view of the entrance of the venæ cavæ into the right auricle of

the heart; the superior is marked *v, c, s,* and the lower, *v, c, i.* In the same figure is shewn how the dark blood collected into the auricle passes next into the right ventricle by which it is driven into the pulmonary artery, *a, p,* to be conveyed to the lungs. This is the only artery in the body which carries dark blood, as the veins I am about to describe are the only veins carrying bright or arterial blood.

Pulmonary Veins.

These veins, perfectly represented in Fig. 1, Pl. 3, are four in number; they may be seen *in situ,** in the figure, and by a mistake of the colourist have been coloured dark, or blue, instead of bright red. They are drawn as they come from the lungs, right and left, in which they originate, in the extremities as is supposed of the pulmonary arteries, or in the intermediate capillaries. They enter the left auricle, *o, g,* of the heart; the blood they convey to this cavity is next propelled by the auricle into the left ventricle, *v, g,* and by means of this powerful muscular cavity, it is forced into the aorta, through which and its branches it is distributed to all parts of the body. In the figure, *v, d,* represents the right ventricle, and *v, g,* the left ventricle of the heart.

II.—Of the Arteries.

Properly speaking there are but two arteries in the body: the pulmonary artery carrying dark blood, and the

* *In situ:* undisturbed; in its natural situation or position.

aorta. The former proceeds to the lungs; the latter carries only arterial blood, and by means of innumerable branches supplies all the organs of the body with the blood they require.

The pulmonary artery (*a, p,* Fig. 1, Pl. 3), starts from the right ventricle of the heart in front of the aorta, and proceeding upwards soon divides in the adult into two large branches, called the right and left pulmonary arteries. The right passes behind the arch of the aorta, the left in front of the same vessel as it descends. They proceed to the right and left lungs. Three semi-lunar* valves exist at the commencement of the pulmonary artery: they prevent the return of the blood into the ventricle when it has left it.

The aorta (*a, o,* Pl. 2, Fig. 1, Pl. 3, and several others; also in Fig. 1, Pl. 4), leaves the left ventricle of the heart, and like the pulmonary artery has three semi-lunar valves at the commencement. After ascending through the chest until nearly on a level with the upper margin of the sternum, the aorta forming a remarkable arch, crosses towards the left side, and reaches the left side of the spinal column on a level with the fourth dorsal vertebra. It now descends along the front of the spinal column, (Plates 2, 3, and 4), gradually becoming more mesial, passes behind the midriff or diaphragm between its columns or pillars, and having reached the fourth lumbar vertebra divides into two great branches called the common or primitive iliac arteries. (See Plate 2, deep layer of the figure).

* Semilunar: of the shape of the half-moon.

In this course there arise from the aorta a great number of branches, in the following order:

a. Cardiac arteries—to the heart.
b. Arteria innominata—nameless artery, which, subdividing, gives off:
 1. The right subclavian—to the arm.
 2. The right carotid—to the head.
c. The left common carotid—to the head.
d. The left subclavian—to the left arm.
e. The bronchial artery—to the bronchi.
f. The œsophageal arteries—to the gullet.
g. The intercostal arteries and phrenic.
h. The cœliac axis, dividing into:
 a. The hepatic—to the liver.
 b. The splenic—to the spleen.
 c. The coronary—to the stomach.
i. The superior mesenteric artery; and
j. The inferior mesenteric artery—to the intestinal tube.
k. The renal, or emalgent—to the kidneys.
l. The spermatic.
m. The intercostal and lumbar.
n. The middle artery of the sacrum, which some consider, notwithstanding its diminutive size, as the real continuation of the aorta.

The common iliac arteries send off each the following arteries:

The iliac subdivides into:

 a. External; and
 b. Internal iliac.

1. External iliac gives off:

a. The oblurator and epigastric.

It is next called the *common femoral,* and under this name gives off some small branches. It soon subdivides into:

1. Superficial femoral; and

2. Deep femoral; this supplies the deep muscles of the thigh; the former, the superficial, descends through the thigh into the popliteal space, where it is called the popliteal artery, afterwards subdividing into:

Posterior tibial,
Anterior tibial, and
Fibular.

The plantar arteries supplying the foot arise from the posterior tibial.

To return to the upper extremity, which is supplied by the subclavian. This artery, after reaching the axilla, is called axillary. It gives off the great muscular branches supplying the shoulder, and in the arm is called brachial or humeral. At the bend of the elbow, it usually subdivides into two branches: *a.* the radial; *b.* the cubital, or ulnar. From these come all the branches supplying the fore-arm and hand.

III.—The Heart.

The exterior and interior of the heart have been figured in various plates of the Atlas. In Pl. 2, it is represented *in situ,* placed on the diaphragm on which it rests; its posterior surface may be seen on raising up the first layer of the engraving. In Pl. 3, there are five views of the

heart, to which I shall refer in the following description of the organ. In Pl. 4, there are also five distinct views of the heart. In Pl. 5, Fig. 1, there is a view of the heart as seen enclosed by the pericardium; in order to see it, the first layer of the plate must be raised up.

A popular error, of countless ages of duration, has assigned to the heart, functions which it has not and cannot have; and the language of nearly all nations has consecrated this delusion. In the heart were placed the passions and feelings of the mind, and a hard heart, a bad heart, and a kind heart, expressed, in brief terms, the amount of the error which ascribed to a hollow muscular organ, insensible under ordinary circumstances, the great, and noble, and tender passions which ornament or dishonour humanity. But, although such delusions are and have been long exploded, enough of interest still attaches to this organ to render it worthy of all attention; its mysterious, unceasing, rythmic action, hitherto unexplained; the strength and peculiar character of its muscular fibres; its supply of nerves and of nervous power from a source which seems to remove it, and does remove it from the control of the mind or will, and the unknown ways by which, notwithstanding, it betrays the secret feelings of the soul, becoming the tell-tale of that of which it can know nothing; the necessity which connects its motions with life;—all these are points which give to its anatomy an interest, second only to the brain itself.

The pericardium (Pl. 5, Fig. 1) is a fibro-serous bag, enclosing the heart on all sides, and with it a portion of the large vessels entering and leaving the organ. Its smooth serous layer is so reflected from off the fibrous

layer of the membrane, as closely to envelope the substance of the heart itself, and thus to form a shut sac, into which there is no opening, as is usual with serous membranes wherever they exist. By means of this membrane, and the serosity which constantly bedews its surface, the heart moves freely in the cavity of the pericardium. Adhesions between the two serous surfaces which the sac of the pericardium presents, result from inflammation, and impede the actions of the heart, interfering with its healthy exercise; but to what extent has not yet been determined by pathologists.

The heart itself (Pl. 2, 3, and 4) is fixed in its position by the fibro-serous membrane just described, and by the great vessels which leave and enter it. It is a hollow muscular organ, composed of four distinct cavities—namely, a right auricle (*o, d,* Pl. 2), and a right ventricle (*v, d,* Pl. 2; also, *o, d, v, d,* Pl. 3), which communicate with each other, but which have no direct communication with the left auricle (*o, g*) and left ventricle (*v, g,* of the same Plates), which also communicate with each other. The outer surface of the heart is covered with a layer of serous membrane, and a fine lamina of cellular tissue; the interior of all the cavities (seen in Fig. 2 and 3, Pl. 3) is also invested with a fine membrane, continuous with that of the great veins and arteries. In addition, it is generally admitted that the inner membrane of the auricles is elastic, which is not the case with that of the ventricles. The volume of the heart varies much in different individuals; it ought, when quite healthy, to be about the size of the closed hand or fist of the individual to whom it belongs. The descriptive anatomist speaks of the base, the apex,

the anterior and posterior surfaces, the right and left margins, all of which will be readily understood by a reference to the Plates.

The arrangement of the muscular fibres of the heart is extremely complex, and has given rise to many minute inquiries; it will be sufficient here to state, that the heart may be viewed as formed of two muscular sacs, contained in a third, common to both ventricles.

It is usual to commence the examination of the heart with the right auricle (*o, d*). Into this enter the two great veins called *cavæ* (*v, c s, v, c, i*, Pl. 2), the superior and the inferior, and, in addition, the coronary vein. At the entrance of the inferior cava is the Eustachian valve, pointing to the remains of the foramen or aperture in the partition of the auricles which existed in the fœtus, but which closes after birth; at the entrance of the coronary vein is the valve of Thebesius.

The right auricle communicates with the right ventricle by an opening called the right auriculo-ventricular orifice. Around the entrance of this opening is placed the tricuspid, or triglochlin valve (seen in Fig. 2, Pl. 3). The walls of the right ventricle are by no means so strong as those of the left, bearing to the latter the ratio which the resistance the blood meets with in the lungs as compared to that it encounters in the body.

The pulmonary artery (*a, p*, Pl. 3, Fig. 1; also, *a, p*, Pl. 2) commences in the right ventricle (*v, d*), and has at its orifice three semilunar valves (seen in Fig. 2, Pl. 3), to prevent the return of the blood into the ventricle when it has once left it.

The left auricle (*o, g*) presents few objects of interest:

we observe in it the orifices of the four pulmonary veins bringing the blood from the lungs, and the left auriculo-ventricular orifice (seen in Fig. 3, Pl. 3), by which it communicates with the left ventricle. Around this orifice is placed the mitral valve, and at the exit of the aorta, which springs from this ventricle, there are, as in the pulmonary artery, three semilunar valves, of a strength corresponding to the parietes, or walls of the artery.

Between the auricles and ventricles is placed a cartilaginous ring, or base, to which both, but more especially the ventricles, are attached. In certain animals, as in the ox, this cartilage ossifies with years, and forms the *bone* of the heart, which has given rise to so much idle speculation since the period of Galen to the present day. It does not ossify in man.

When the valves ossify, they impede the flow of the blood in its onward course, and cause violent disturbances in the animal economy. Man is much subject to disease of the heart, especially to that called hypertrophy, or morbid enlargement of its muscular walls.

CHAPTER V.

Of the Circulation of the Blood.—Physiology.

The heart is the centre or chief agent of this great function. It drives the blood through the arteries to the remotest parts of the body, and it assists, no doubt, in urging it through the veins by which it is again returned to the same organ. Thus all the blood in the body is

constantly circulating or passing through the four cavities of which the heart is composed. It is a double heart, being, in fact, composed of two, quite distinct from each other; hence the terms right and left hearts, pulmonic and systemic—heart for the dark or venous blood, heart for the bright or arterial blood. This last application is the best, as it is strictly correct, which is not the case with the others. In point of fact, the right auricle and ventricle contain only dark or venous blood, whilst in the left auricle and ventricle is collected the arterial blood fresh from the lungs.

In Pl. 3, Fig. 1, *c*, the heart is represented *in situ*, and covered with the pericardium, that is, the fibro-serous bag containing it. The letter *c* is placed, properly speaking not on the heart, but on the pericardium. In Pl. 2, the heart is more fully shewn, the pericardium having been completely removed, together with the greater part of the right and left lungs; *o, d,* mark the right auricle which receives into it all the dark blood of the body; *v, d,* the right ventricle into which this blood is poured from the auricle; and *a, p,* the pulmonary artery through which the dark blood passes to the lungs.

These two cavities constitute the right or anterior heart formed for the service of the lungs. In Pl. 4, Fig. 2 and 3, may be seen the left heart, composed of the left auricle and ventricle; these receive the arterial blood fresh from the lungs, and by the ventricle it is driven with much force through the aorta and its branches into every part of the body. Returning from the tissues by means of the veins once more into the left auricle, having in its

course passed through the right auricle, ventricle, pulmonary artery and pulmonary veins; these movements, I have just described, constitute the pulmonic and systemic circulations. The reader will readily comprehend that in the normal condition there exists no communication between these two hearts in the adult. In the fœtus, before birth, it is otherwise; but into this I need not enter here.

Four muscular sacs constitute the human heart; their minute anatomy has been given in the preceding chapter. This form of heart holds good in all mammals and birds; in animals, lower in the scale, there exist other arrangements; and it is a remarkable fact that the human and mammalian hearts gradually pass through all the forms the heart assumes in the lower animals in the course of its development. On such facts, admitting of no sort of doubt is based the whole system of transcendental or philosophic anatomy and physiology.

It is in the capillaries of the lungs, interposed between the external branches of the pulmonary artery, and the radicles or roots of the pulmonary veins that the conversion of the venous into arterial blood takes place.

The heart forms a forcing and sucking pump which drives its contents onwards through the tubes we call vessels. Its muscular walls contract and relax alternately to expel and to receive the blood alternately. The right auricle and ventricle contract and relax alternately and in rapid succession, and the left cavities do the same. The state of contraction is called systole, and that of relaxation dinstole, and a beat of the heart comprises that space of

time in which each of its four chief compartments has undergone one contraction and relaxation.

The two auricles contract simultaneously, and next the two ventricles; whilst the auricles contract, the ventricles are relaxed and vice versâ; hence arises the rythm or rythmic action of the heart.

This rythmic action takes place, as I ascertained, in the following manner: I observed it first in the heart of the shark, after being removed from the body. The action commenced in the great vein entering the auricle; the contraction is next taken up by the auricle, and when this ceases, the ventricle follows. I never observed these actions to be reversed. The ventricle never acted of itself, but was sure to follow the auricle in its action; but the auricle still acted after the ventricle had ceased to act, and the part in which it seemed to continue the longest was the point where the great veins enter the auricle.*

It is probable that all the cavities of the heart have a nearly equal capacity, and that their walls possess a slight degree of elasticity. During the systole of the ventricles, the apex of the heart is raised, and indeed the whole heart; it is this which causes the point or apex to beat against the walls of the chest: this phenomenon takes place even when the heart of an animal just killed has been removed from the body and placed on a table; it also happens, although the auricles have been cut away, shewing that the action depends wholly on the ventricles.†

* Edinburgh Medical and Surgical Journal, 1821.

† This independent action of the ventricle is not rythmic, but uncertain and irregular.

During tranquil respiration the beating of the human heart may be distinctly felt between the fifth and sixth ribs of the left side; the cause of the visible stroke of the healthy heart has been much enquired into and disputed, but hitherto without success. Equally obscure is the source of the sounds we hear when the heart beats violently, or when placing the ear against the walls of the chest, we listen to the pulsations of the heart. It may be admitted, however, that the first sound coincides with the contraction of the ventricles; the second, with their relaxation; and that the sounds are probably valvular, or connected with the shutting of the auriculo-ventricular and semilunar valves.

The elasticity of the arteries, no doubt, assists in the circulation of the blood; and it would even seem that the living arteries are capable of gradually altering their diameter under various circumstances. In those parts of the body where arteries of considerable size lie close to the integuments they may be seen to move; but this motion is not, properly speaking, the pulsation or beating of the artery; it is merely a kind of locomotion or displacement of the arterial trunk caused by the endeavour which every bent and elastic tube makes to become straight when filled by a fluid acted on by a propelling force or pump. The true pulsation which for convenience we examine at the wrist, by slightly compressing the radial artery, is a phenomenon caused by the diminution of the calibre of the artery pressed on by the finger of the observer. At this moment, we feel the propulsion of the wave of blood acted on by the heart, and to this feeling we give the name of

the pulsation of the artery, although in fact the artery has little or nothing to do with the phenomenon.

The frequency of the heart's pulsation varies with the age, and is also influenced by a variety of other circumstances, as, the position of the body, exercise or rest, food, &c.; perhaps, also, the height and weight, though this has not been clearly made out. The average pulse of a healthy adult man, standing erect, at about noon time of day, is about 70 or 74; but it sinks by 5 or 6 beats if he sits down, and still more if he assumes a horizontal position. Moreover, the pulse, as I proved long ago,* undergoes a diurnal revolution, that is, increasing constantly from three or half-past three in the morning nearly to noon, when it is at its maximum of number, strength and excitability, and decreasing to the same hour of three in the morning when it is at its lowest. The heart's action diminishes in old age, but some physiologists are of a contrary opinion. As a rule, there are from three to four beats of the heart for every inspiration.

The ordinary weight of the human heart ranges between six, seven, and thirteen ounces. The mean time of the circulation has also been made the subject of numerous experiments, from which it has been calculated that the duration of one circulation of the whole mass of blood occupies about two minutes.

The left ventricle ceases to act before the right; and the right ventricle ceases its action before the right auricle. Hence Haller called this part of the heart, the *ultimum*

* In 1813 and 1814.

moriens, or the last to die. The law probably applies to most animals, at least it seemed to me to hold good in fishes. In some of these, as I have already remarked, the rythmic action of the heart always commenced in the auricle, and in the large vein entering it, and the ventricular action followed. As the heart lost its power of contractility, motion ceased first in the ventricle; the vein contracted even after the auricle had ceased to act.

CHAPTER VI.

OF THE BLOOD.

(Pl. 3, Fig. 6).

This all important fluid in the animal economy has been subjected to the most careful analysis by physiologists and chemists. The principal facts respecting its composition are as follows: the blood of the adult male contains 77·9 per cent. of water, and 22·1 of solid residuum. The latter consists of 14·1 parts of blood corpuscles, 6·9 of albumen, ·2 fibrine, ·2 fat, and ·7 of extractive matters, and salts. Thus the fibrine which apparently enters so largely into the coagulated blood constitutes, in reality, but a small quantity of its mass.

The blood of the female contains, on an average, more water and fewer corpuscles; it is said to have a greater

density in the new-born infant than in the female at the close of pregnancy.

The spontaneous coagulation of the blood is one of its most remarkable qualities; whilst in the vessels it represents a flowing mass of a homogeneous liquid; on being withdrawn from these it separates after a time into two distinct portions, called the serosity and the clot or crassamentum. This appearance occasionally does not take place, and this has been said of those who were killed by lightning. The clot contains the blood globules, (Pl. 3, Fig. 6), and large quantities of serum; but they may be separated from each other by mechanical means; the colour of the blood depends on the red globules.

The blood has been seen of a milky colour; but this is rare. Blood may be transfused from the vessels of one animal into those of another, and this has been practised even in man, in cases where much blood had been accidentally lost; but it frequently happens that an animal dies shortly after the injection of the blood of another species.

Many physiologists following Mr. Hunter have maintained that the blood is alive whilst moving in the vessels. One thing seems certain; the whole mass of blood may be made to undergo a process of fermentation by a mere drop of an infected liquid. In this way the vaccine virus acts, and no doubt the small-pox, and many other poisons.

How the food or the chyle is metamorphosed into blood is not known; and we are equally ignorant of the mode of transformation of the blood into the tissues composing the body.

The quantity of blood in the human body has been estimated at 28 pounds.

Animal Heat.

Connected with the blood and with respiration, the question of animal heat may be appropriately considered here.

In man the heat under the tongue averages 98·6 to 99·1, but it is higher in some other mucous passages. Under ordinary circumstances the external integuments or skin vary between 89·6 and 97·7.

But many of the deeper parts of man and mammals have a higher temperature: as, 104·5, 106·3, and 106·5.

Age makes no difference in the temperature of the skin: from one year old to eighty it is always the same—nor does climate, nor race. During the cold stage of ague, the skin remains of its usual warmth, or even becomes warmer.

It is probable, as explained in the Chapter on Respiration, that the animal heat is generated by the process of combustion constantly going on in the organism.

Birds are certainly somewhat warmer than mammals, whilst reptiles and fishes are naturally much colder.

CHAPTER VII.

OF THE ORGANS OF RESPIRATION (PL. 2 AND PL. 3, FIG. 1).

THE LUNGS.

Anatomy.—The engravings accompanying this work furnish sufficient means for the right comprehension of the mechanism of respiration. In Pl. 1 may be seen the cavity of the chest, in which the lungs are contained. These are, of course, the true organs of respiration in man. The inferior limits of the cavity are pointed out by the red line marking the course of the diaphragm, *septum transversum*, or midriff, the great muscle of respiration, and which also serves the office of separating the cavity of the chest from that of the abdomen; the posterior walls, osseous and muscular, are also well seen here; the anterior have been removed, and with it all, or nearly all, the viscera contained in the cavity of the chest.

By turning to Pl. 5, the reader obtains another and a still more important view of the organs we now consider. In this Plate, all have been left in their natural situation, undisturbed. Raise up the first layer of the dissected Plate (Fig. 1), composed of the breast bone, and a portion of the ribs and intercostal muscles, and the anterior wall of the abdominal cavity, and observe the right and left lungs, *p, p, in situ,* filling, together with the heart, *c,* the cavity of the chest. They rest on the diaphragm, *d,* separating, by a well marked red line, the cavity of the chest from that of the abdomen.

Next turn to Pl. 7, Fig. 2, and observe a view of the same organs, than which there can be none more instructive. By raising up the first layer of the figure, we discover the whole extent of the right lung *in situ*, showing its great size when fully expanded, its apex running up towards the neck, its base resting on the diaphragm, and descending behind as low as the last dorsal vertebra, or nearly so; lastly, the form of the three lobes into which this lung is naturally divided. No description could be given expressing so clearly the relations of the right lung to the surrounding organs.

Upon raising up the second layer of the figure, and reversing it, we get a view of the left side of the left lung, and of the heart, enclosed in its pericardium. This lung is composed of two lobes; its relations to the surrounding organs need not be further described.

In Pl. 2, we have a view of the dissected and corroded lungs, showing, as is done in anatomical preparations, the distribution of the great blood-vessels and nerves to these organs. By raising up the first layer of the figure, we get a view of the posterior surface of both lungs, undissected, and their relation to the cavity in which they lie.

Lastly, in Pl. 4, Fig. 1, we have a view of the lungs, together with the trachea, or wind-pipe, and bronchial tubes, in which the trachea terminates, removed wholly from the body, and placed on their anterior surface. The lungs are marked *p*, *p*; the aorta, *a*, *o*; the wind-pipe, *t*; the right terminating branch of the wind-pipe, *b*, *r*, (right bronchus); the left auricle of the heart, *o*, *g*. By placing these various figures before him, the reader will be able,

by means of the following brief description, clearly to comprehend the anatomy of those organs, the respiratory, so essential to all that lives.

I.—The Lungs and their Appendages.

The lungs (pulmones*) are two spongy, cellular, expansible organs, contained within the cavity of the thorax, separated from each other by the mediastina† and the heart, partially surrounded by the pleuræ; they are the essential organs of respiration.

Although the lungs are, to all appearance, separate and distinct, they are yet really connected with each other, since they receive the air by a single canal, and as the blood is transmitted to them by a single vessel. Their volume is not equal, however, but, on account of the projection of the diaphragm on the right side, caused by the liver, and the obliquity of the mediastinum to the left, the right lung is thicker than the left, which, in its turn, has a greater vertical extent; the left lung is also a little smaller than the right. The volume of the lungs is exactly proportioned to the capacity of the cavity of the thorax. They follow the motions impressed upon its walls, against which they are always applied, and dilate and contract like them; nor does any vacuity ever exist during life between that part of the pleura‡ which covers

* Pulmo, a lung; hence pulmonary, pulmonic, &c.

† Cavities and their partitions already described in several notes.

‡ The pleuræ are two serous membranes placed within the cavity of the chest. They partially cover the lungs, and invest the walls of the chest, or thorax.

the lungs and that part investing the walls of the chest. It is here, however—*i. e.*, in the so-named cavity of the pleura—that water sometimes accumulates, forming hydrothorax, and purulent matter, forming the disease called empyema; and sometimes even air, as in pneumo-thorax; but all these are diseased conditions of the organs.

The lungs are proportionally much lighter than the other organs; they never sink in water so long as they are in their natural state, and their lightness depends upon the air, which penetrates their whole tissue. In infants which have never breathed, the lungs generally sink in water. But the absolute weight of the lungs varies much in different individuals, which may depend upon the greater or less quantity of blood that remains in them at the moment of death, or upon a larger development. It is also to be observed that, in children which have not breathed, the lungs are, with respect to the total weight of the body, in the variable relation of 55 or 70 to 1; whereas, the proportion is as 28 or 35 to 1 when respiration has taken place. The act of respiration, therefore, diminishes their gravity in a great degree, a circumstance which it is of importance to know, with reference to medical jurisprudence. The colour of the lungs, in the healthy and adult state, is a pale yellowish red, more or less approaching to white or grey. The younger the subject, the redder will be the lungs. This tint is equally observed in the interior and at the exterior of the organ. But if the blood happen to be too much accumulated in its parenchyma, the colour is a dark red or purple, uniformly diffused, or only dispersed in patches, which pro-

duces a marbled appearance. It is for this reason that the lungs are always more coloured on the side on which a dead body has lain. The reddish or greyish colour of the lungs is interrupted by small black and brown spots, irregularly dispersed on their surface, and more or less numerous; they are exactly defined, and in general affect a linear form; they are seldom isolated from each other; some are entirely superficial, others penetrate more or less deeply into the tissue of the lungs, and there are some which seem limited to the pleura, or membrane which immediately envelopes these organs, in the substance of which they also occur. Buisson considers them as analogous to the lymphatic glands of the bronchi.* Of the solid organs of the body, the lungs are those which have the smallest density; they may be compressed with the greatest ease, and only resume their original state imperfectly. Although flexible and soft, however, they have a tissue which is not easily torn. The form of the lungs is not very easy to be described;† it may, however, in a general manner, be likened to that of a cone, having its base directed downwards, and its summit upwards, and flattened internally. The right lung is divided into three unequal lobes (Pl. 7, Fig. 2), by two oblique fissures; the

* Bronchi: the two branches into which the trachea, or wind-pipe, divides, sending one to each lung.

† In Pl. 3 and 4, Fig. 1 and 1, will be found excellent delineations of both lungs, anteriorly and posteriorly. In Pl. 5, there is a view of the lungs *in situ*, represented as they appear during a full inspiration, and as they are generally found after death: and in Pl. 7, Fig. 2, the same organs may be seen in profile.

left (same Plate, reversed) presents only a single fissure, and, consequently, has but two lobes.

Their *outer* surface, which is convex, especially behind, and nearly plane anteriorly, is free *in its whole extent,* and corresponds to the walls of the thorax, from which it is separated by the costal layer of the pleuræ. It is smooth and polished, and constantly bedewed with a serous fluid. On the left lung, it presents a fissure which descends obliquely from the posterior to the anterior edge, and divides the organ into two lobes, a superior and anterior, which is smaller, and a posterior and inferior, which is larger; this fissure nearly penetrates through the whole thickness of the organ. A similar fissure is observed on the right lung; but in it the upper lobe is divided into two portions by a secondary fissure, running obliquely downwards and outwards, and, consequently, in a direction the reverse of the great fissure, and which varies much as to depth and extent. In the two lungs, the upper lobes, which are large above, terminate below in a point, while the contrary takes place in the lower lobes, which are always the larger. In the right lung, the middle lobe is triangular, presenting its summit outwards, and its base inwards, and it is smaller than the other two.

The *internal* surface (roots, Fig. 1, Pl. 3, and Pl. 2) of the lungs, which is plane or slightly concave, to accommodate itself to the shape of the heart, corresponds, posteriorly, to the posterior mediastinum and vertebral column. About the middle of its height is seen the insertion of the bronchi and pulmonary vessels (Fig. 1, Pl. 4).

The *anterior* edge of the lungs is thin, sharp—especially

below—oblique, sinuous, more or less uneven, directed obliquely downwards and forwards, and notched on the left side only, to receive the point of the heart.

Their *posterior* edge is thick, rounded, nearly vertical, and lodged in a groove which the ribs form on the sides of the vertebral column.

Their *base*, which is slightly concave, rests upon the upper surface of the diaphragm (Fig. 1, Pl. 5), and is inclined a little downwards and outwards on each side.

Lastly, their *summit*, which is narrow, obtuse, and a little bulgent, is situated generally in the neck, a little above the level of the anterior part of the first rib.

Organization of the Lungs.

The tissue of the lungs is very complicated. It seems essentially composed of prolongations and successive ramifications of the bronchi or air tubes, and pulmonary arteries and veins, which stick together in all their divisions, and are sustained together by a very fine cellular tissue, so as to constitute a series of lobules, covered and united by the pleuræ, and interspersed with nerves, vessels, and lymphatic glands. Reseissen thought that the bronchial tubes terminate in air cells.

II.—The Trachea.

The trachea, (Fig. 1, Pl. 4, and Fig. 1, Pl. 3), (arteria aspera; windpipe), is a cylindrical, cartilaginous, and

membranous tube, a little flattened posteriorly, (as seen at Fig. 1, Pl. 4), placed before the vertebral column, extending from the lower part of the larynx, (*l*, Pl. 3, Fig. 1), opposite the second or third dorsal vertebra, in the posterior mediastinum. Running along the median line of the body, symmetrical and regular in its whole extent, slightly mobile and extensible, the trachea has a uniform diameter of about 8 or 10 lines, which varies only according to the age, and certain individual peculiarities.

Inferiorly, the trachea bifurcates, dividing into the two bronchi, which are distinguished into right and left, and which separate from each other, directing themselves downwards and outwards at nearly a right angle. The bronchi proceed one to each lung.

The trachea and bronchi are composed of:

1. Cartilaginous rings. 2. Membranes. 3. Arterial and venous vessels. 4. Lymphatics. 5. Nerves. 6. Mucous follicles. 7. Bronchial glands.

1. The *cartilaginous rings* are from sixteen to twenty in number; they are not complete rings in man, being interrupted in their posterior third. By their convex surface they correspond to a fibrous membrane, (Pl. 4, Fig. 1, *t*), and by the concave are in connection with a mucous membrane. The colour and consistence of the cartilages of the trachea and bronchi are the same as in those of the ear, the apertures of the nose, &c. Their elasticity is very remarkable. They seldom ossify, even in the most advanced old age.

2. The *fibrous* or *outer membrane* comes from the in-

ferior circumference of the cricoid cartilage,* and is prolonged to the last extremities of the bronchi, becoming gradually thinner to an excessive degree.

3. The *mucous* or *inner membrane* is a continuation of the membrane of the larynx, and extends to the termination of the bronchi.

III.—Organs of Respiration—Their Functions or Physiology.

The phenomena connected with respiration are partly mechanical, chemical and vital. The object of the function is to expose the venous blood to the action of the air during its passages through the lungs, and by its means to convert it into arterial blood. On this life depends.

When distended with air, the lungs of an adult man weigh from about 18 to 53 ounces. About 308 ounces of blood pass through the lungs of a strong man every minute.

Respiration is composed of expiration and inspiration. The former is effected, when natural, by the mere elasticity of the tissues displaced by the act of respiration: in other words, as soon as the muscular effort which causes inspiration ceases, expiration commences; it requires no effort.

Ordinary tranquil inspiration is effected by means of the contraction of the diaphragm; but deeper respiration requires the assistance of many other muscles. Of these

* Cricoid cartilage: the inferior cartilage of the larynx, or organ of voice.

the most remarkable are the intercostal muscles producing the play of the ribs. The first act of respiration seems to be the dilatation of the nostrils, next that of the chest; by this dilatation the air rushes into the lungs which follow, of course, the dilatation of the chest; even the glottis, or air chink of the larynx, dilates during inspiration. The series of actions constituting respiration seem to me to be nearly as rythmical as the action of the heart.

Some animals breathe only through the nostrils; others, as man, by mouth or nostrils indifferently. A certain quantity of air is always left in the lungs even after the deepest expiration.

A considerable amount of watery vapour escapes from the lungs at each expiration, and with it a quantity of carbonic acid gas. The amount of vapour has been estimated at 14 ounces in the 24 hours.

It has been asserted that the vital capacity of the lungs varies with the height of the body; the volume of air increasing eight cubic inches for every inch of height. The volume of carbonic acid in the air expired in ordinary respiration, ranges between 4 and 4·5 per cent. The number of inspirations per minute ranges from 20 to 40. As much as 504 grains of carbonic acid gas are given off per hour. A certain amount of oxygen disappears in the lungs, seemingly absorbed by the blood. The presence of oxygen in the air is essential to life.

Experiments made on expert divers shew that the respiration cannot be interrupted for more than six minutes without causing death.

CHAPTER VIII.

ON THE SECRETIONS AND EXCRETIONS.

We have already seen how the blood requires to be purified by various secretions, some of which besides serving this important purpose, assist in the nutrition of the body. As the subject is one of much importance I have thought it might be useful to superadd a chapter especially devoted to it.

The simplest form of secretion probably prevails on the surface of the arachnoid membrane of the brain and spinal marrow, and on serous membranes generally; and under the same head may be included the synovial membranes of the joints and of the bursæ mucosæ. No glandular structures, properly so called, have been observed in these membranes.

The structure of the secreting glands is based upon the formation of depressions, which under other circumstances become tubes and cavities. In Pl. 8, Fig. 10, will be found a diagram of a cutaneous gland, such as is called a spiral or perspiratory gland. The common duct first divides into two subordinate tubes which are then variously coiled upon each other. But nature is not bound by these types of structure. The tubular form by multiplying the secreting surface extends it to an almost incredible degree, and it has been calculated that in a single kidney, the secreting surface equals 48½ square feet.

To some of the secreting organs large arteries are sent, supplying a rapid and ample secretion; and to one, the liver, there is also distributed a large vein, the portal vein, carrying much blood to it.

The organs I now speak of with reference to their functions have ducts conveying the secreted matter away from the formative organ. These ducts most frequently have one layer at least, of their walls, muscular, composed of unstriped muscular fibres.

a. The Secretion of the Skin, (Fig. 10, Pl. 8).—The skin of an adult man forms a surface of about 2325 to 2550 square inches. Watery vapour is constantly passing off from the skin, which when it becomes sensible is called the sensible perspiration. This fluid contains chloride of sodium and ammonium and phosphate of lime with other salts and organic matters. The skin contains epithelial scales and fatty substances. In many portions of the skin are found *sebaceous glands,* secreting a fatty matter. Under this head have been arranged the glands which secrete the wax of the ear, those called Meibomian, which form an analogous substance on the edge of the eyelids, and those which are formed at the roots of the hair.

b. Serous Secretions.—These have been already alluded to. When they accumulate to a certain extent, they form dropsies of the serous and synovial membranes: that is, of the great cavities and joints.

c. Mucus.—Mucus is not a simple secretion. It is produced in two ways: in special glands or on free surfaces. As glands they are found scattered over various parts of

the stomach and intestines, where they are called lenticular, solitary and aggregated.

d. The Synovia stands, as it were, midway between the serous and mucous secretions; it is prepared by the synovial membranes themselves and not by any glandular apparatus.

e. The Lachrymal Secretion, (or the tears), is formed in the lachrymal gland, (Pl. 8, Fig. 4, *g*), and is of sufficient quantity to moisten the surface of the eye at all times. The superfluity, as we have already explained, is discharged by the nasal duct into the inferior meatus of the nostrils. See the representation of the lachrymal apparatus in the same figure.

f. The Saliva.—This secretion and the source from whence it comes have been already alluded to. Some still consider the pancreas as being simply a salivary gland, and it has been asserted that dogs undergo extirpation of the pancreas without injury.

g. The Bile.—The liver (Pl. 1), is distinguished from all the other glands by a peculiarity in its circulation. It receives besides the hepatic* artery, the portal vein; and many enquiries have been instituted to discover the object or uses of this re-circulation of venous blood, but as yet no satisfactory results have followed such enquiries.

It has long been supposed that the formation of bile was necessary to the purification of the blood, but Liebig shewed that but little bile was excreted, and that the greater portion was, in fact, reabsorbed in some form or another. Mercury, which in some persons causes a flow of

* Hepatic: from hepar, the liver.

bile, stops it in others; whilst the passage of bile in large quantities hurriedly from the intestines, constitutes a formidable disease.

h. The Secretion from the Kidneys, (Plate 2, *r, r*).—These organs are probably the most active of all the secreting glands, (Pl. 4, Fig. 5, and Plate 2, *r, r*). Their general structure may be seen in the dissected view in Plate 2. The secretion withdraws from the blood superfluous water, and soluble ashy constituents; at the same time it carries off certain azotized substances which cannot otherwise be got rid of. Of these the most remarkable is the substance called urea; but, in addition, we find uric acid, hippuric acid; kreatin, oxalates, carbonates, phosphates and sulphates, &c. It has been conjectured that the urea originates in the blood.

The destruction of one kidney does not in general affect the health of the animal; but when both have been destroyed death speedily takes place.

CHAPTER IX.

ON THE VASCULAR GLANDS.

Nothing shews better the defective state of human and comparative physiology than the profound ignorance which still prevails respecting the uses of certain organs of the body, which in the absence of facts, and somewhat indeed

against the evidence of sense and experience have been called vascular glands.

Of these the most remarkable is the spleen ; next follow the thyroid, the supra-renal capsules, and the thymus. This latter, however, rather belongs to infantile life, as it all but disappears before eleven or twelve years of age.

All these organs have been called glands without ducts. The spleen enlarges generally during agues, and this enlargement is quite as mysterious as its function.

The *supra-renal** capsules are comparatively large in the new-born infant; but they maintain their structure to the adult state, and indeed throughout life.

The *thyroid gland* is another of these mysterious organs, whose functions are unknown. Enlargements of this body are common enough in various counties of England, and in Scotland, and the disease is endemic in the valleys of Switzerland.†

The *thymus* reaches its greatest bulk in the earlier years of childhood. It then becomes stationary, and after a time all but disappears. When the thymus continues developed or of considerable size in the adult, it would seem to be connected with a feebleness of intellect; I have at least observed this to happen in two cases.‡

Some may be disposed to view this fact, were it proved to be constant, as merely a result of the continuance to

* Called super-renal, as being placed immediately above the kidneys.

† The thyroid gland, or body, is situated on the front and sides of the superior portion of the trachea, or wind-pipe.

‡ The thymus is situated in the upper part of the chest and lower portion of the neck. It rests on the trachea and upper part of the pericardium.

the adult state of fœtal or juvenile structures, and thus include it in the category of "arrested developments," a theory which Meckel and the German anatomists made extremely fashionable some time ago. The continuance, however, of such organs in a full state of development to the adult condition cannot correctly be called "an arrest of development;" but it may be placed under another category, that of "retrograde development," a profound theory which we owe to Goethe.

GENERAL CONSIDERATIONS

ON

THE STRUCTURE AND MECHANISM

OF THE

HUMAN SKELETON

AND OF

THE MOVEMENTS OF THE HUMAN BODY.

CHAPTER 1.

The human skeleton (Plates IX. X. and XI.) is, as was to be expected, in perfect harmony with the high destinies to which the nervous system in man is especially called. Its proportions (I allude, of course, to the antique Greek models) are perfect; and the movements it admits of when acted on by the muscular system, elegant and impressive beyond what language can well describe. It has been usual hitherto, to divide the skeleton into trunk and limbs: the former into head, chest, and pelvis; but such divisions and subdivisions are wholly unphilosophic; not even artistic, and beneath the current philosophy of the day.

The vertebral column is the essential part of the skeleton; all other osseous structures may be viewed as its appendages. This vertebral column, (which includes the

head (cephalic* vertebræ) occupies the median line of the trunk. It is a column made up of many parts or separate bones, strongly articulated with each other, vertical, straight in one sense, symmetrical and elastic. It is the common centre of all the movements of the body, and its curves, for it has several, are full of grace and beauty. (See the profile, Pl. XI).

A canal for containing the spinal marrow and its membranes, traverses the column throughout its whole length (Pl. 7. fig. 2. deep layer). By being composed of a series of broken levers, admitting of a most extensive range of movements, never angular, this delicate organ, the spinal marrow, is protected, under all ordinary circumstances, from sudden injury or pressure.

Four curves (see the profile view) are present in the column, corresponding to the neck, the back, the loins, and the pelvis: and this arrangement has been supposed to add to the strength of the column, as it most certainly contributes to the beauty of its form. Thus the column alternately, and in an instant, assumes the character of a lever broken at many points, or of an inflexible pillar of support, according to the action of the muscles employed; its flexibility and elasticity depend on the fibro-cartilaginous bodies connecting the bodies of most of the vertebræ to each other; and thus are successfully resisted the effects of shocks on the brain, which, if communicated through an unbroken solid lever, would, no doubt, prove immediately fatal.

The five regions into which the column has been

* Cephalic, from *kephale* (Gr.), the head.

divided, exclusive of the head, merit further notice. 1. The cervical region is composed of seven vertebræ, all more or less moveable on each other, and on the head. To some of these vertebræ, specific names have been given; thus, the first is called the atlas; the second, the dentata, toothed vertebra or axis; the seventh, the vertebra proeminens. The meaning of these terms is as follows: the first vertebra is named atlas from supporting the globe of the head. The articulation between the atlas and occipital bone is a ginglymoid, or hinge-like joint, very secure and admitting of motion only in one direction, that is, backwards and forwards. No lateral motion is admissible here. The second vertebra, on the contrary, is articulated with the first by means of a remarkable tooth-like process carried on the body of the vertebra, around which process the atlas rotates, carrying the head with it.

Thus the rotatory motions of the head, take place between the atlas and axis, and these motions are rigorously limited to a semi-rotation, by check ligaments of great strength; the seventh vertebra is called *proeminens,* from the projection of its spinous process backwards, beyond the line of the preceding cervical vertebræ. It is a remarkable bone, and not unfrequently bears on one side, at least, a striking resemblance to the first dorsal vertebræ, which immediately follows it; the last vertebræ, indeed, in every region resemble more or less the first vertebra of the region which is to follow; the last dorsal resembling the first lumbar; the last lumbar, the first sacral; and the last sacral, the first coccygeal.

The dorsal vertebræ may readily be recognized from all

others, by the smooth articular surface or surfaces, called *facettes,* for the articulation with the heads and tubercles of the ribs; the cervical vertebræ by a foramen or hole at the base of the transverse process for the passage of the vertebral artery; the lumbar by the absence of both these characteristics; the sacral and coccygeal are quite distinct from those of all the other regions, and not readily mistaken for them.

The skeleton of the head is composed of the cranium and face; the former constitutes an osseous envelope, or covering for the brain, and being arched, is proportionally strong on the principles of common mechanics. Its articulations are usually called sutures, presenting serrated, dove-tailed margins; this adds, no doubt, to the strength of the osseous walls of the cavity. Its inner table is comparatively smooth, and is called vitreous, or glassy; the intermediate cancellated structure between the two tables of the skull is called *diploe.* With age, these articulations disappear, and the entire cranium seems occasionally as if composed of one bone. The merit is due to Gothe, of first proving that the cranial bones, are, in fact, vertebræ, and that the head is simply the continuation of the vertebral column.

Although the form of the cranium differs considerably in the varieties of men or races as they are called, yet such differences are not so remarkable as what we find to occur in the bones of the face. Thus, the jaws are of great comparative size in the negro and other dark races of men, whilst they are small in the European. This difference in the projection of the jaw beyond the line of the forehead,

suggested to the celebrated Camper his idea of a *facial angle.*

The osseous cavity of the chest or thorax, presents several circumstances worthy remark. Twelve dorsal vertebræ, twenty-four ribs, and their cartilages, with the sternum or breast-bone in front, compose the osseous and cartilaginous thorax. This cavity is at once osseous and cartilaginous, moveable, elastic, and fixed, as circumstances require it to be. It contains the lungs, heart, and many great vessels and nerves, (Pl. 7, Fig. 2, deep layer; Pl. 6, Fig. 1, deep layer), and is separated from the abdominal cavity by the great muscle of respiration—the midriff or diaphragm.* Numerous muscles, the intercostal and others, shut in its walls, and assist in the acts of inspiration and expiration. The cavity of the chest is conical, and differs in shape in the male and female. The ribs are elastic arches, so strongly articulated with the vertebræ that they are never dislocated, always breaking before this happens. But when broken, they readily unite, care being taken to confine and limit their movements during the cure.

The pelvis or basin composed of the ossa innominata, or nameless bones, and of the sacral and coccygeal vertebræ, is admirably constructed to perform its important functions (see Pl. IX. X. XI.) It is remarkably broad in man, presenting also sexual and important differences. In man the pelvis transmits to the limbs the weight of the trunk and the superior extremities.

The composition of the skeleton of the limbs has been already given in the text (pp. 42 and 43), and the number,

* Also Pl. IX. X. XI.

names and position of the bones in their various regions. A few remarks will, therefore, suffice here, to complete the description already given. The axis of the arm is not the same as the axis of the fore-arm, and thus, when the fore-arm is flexed on the arm, the hands cross each other on the breast. The upper end of the radius is articulated with the humerus, by a smooth round surface, admitting of a rotatory motion, whilst that of the ulna presents a deep cavity, for the reception of the trochlea of the humerus. This form of articulation admits only of a hinge-like motion, and hence at the elbow, there is but one kind of motion, namely, backwards and forwards, or hinge-like. Whence then, the necessity for the peculiar form of articulation we find between the head of the radius and the humerus? Without it, the hand would be useless, or nearly so, for on the rotation of the head of the radius and of its carpal extremity, around the lower end of the ulna depend the movements of rotation and supination of the hand. These are lost whenever the radius is fractured, and by this circumstance, and by the crepitation of the fragments, when rotation is attempted we know what has taken place.

The names of the carpal bones have been already given; the metacarpal are designated numerically, commencing with the one supporting the thumb; the joints of the fingers are called phalanges, and are distinguished as the 1st, 2nd, and 3rd, or proximal, middle and distal; proximal meaning the phalanx nearest the body, and the distal the one furthest from it.

The bones of the lower extremities have been already (p. 43) enumerated and named, and their relative position

and connections pointed out. The femur or thigh-bone is the longest and heaviest bone of the skeleton. It merits special notice from the student; separated from its fellow, by the whole breadth of the true pelvis (see Pl. IX. X. XI.) its rounded globular shaped head is received into the cavity of the acetabulum, forming with it a perfect ball and socket joint. A ligament, called the round ligament, connects the head of the femur to the bottom of the cavity formed for its reception. The part which follows the head is called the cervix or neck, and the angle it forms with the head of the bone seems to vary with age. It is this neck of the bone which is so liable to fracture in aged persons. The shaft of the bone which follows is of great strength and more or less arched in different persons; this terminates in a semi-cylindrical portion called condyles; these rest on the tibia. In front of the joint so formed, is the patella or rotula, a sesamoid bone, developed in a fibro-cartilage placed on the inner side of the tendon of the extensor muscles, and belonging to a system of bones, distinct from those of the skeleton. Two smaller but similar sesamoid bones are constantly present at the articulation of the first phalanx of the thumb and great toe with the corresponding metacarpal and metatarsal bone supporting them.

The entire weight of the body is transmitted from the femur through the tibia to the astragulus; the arch supporting this bone is partly osseous, and partly fibrous and elastic, a mechanism to which I shall return in the following chapter on the movements of the body and limbs.

CHAPTER II.

MECHANISM OF THE MOVEMENTS AND ATTITUDES OF THE HUMAN BODY.* (PLS. 7, 5, 6.)

THE bones constituting the skeleton, are as we have seen, united or articulated with each other in a variety of ways. Some of these articulations are moveable, others not. It is of the first I mean chiefly to speak in this chapter, combining in the view, the movements of the muscles as the means by which the various movements and attitudes of the body are performed and maintained.

Look at the articular surface of a fresh bone, whether of an animal merely or of man, and it will be found incrusted with a cartilage not only elastic, but capable of sustaining the rudest shocks. In addition, we find spread over these cartilages and certain of the adjacent structures, a delicate-looking, yet strong membrane called the synovial membrane. The inner surface of this membrane which forms a closed sac, is constantly bedewed with a viscous substance called synovia or joint oil.

But in addition to these structures intended to give facility for motion, and to protect the bones and other structures from injury and destruction, the joints are further strengthened by ligaments, non-elastic, strong and fibrous, permitting the bones to move only in certain

* For the treatment of this subject in an artistic point of view, see "The Anatomy of the External Forms of Man for Artists." By Fau. Edited by R. Knox, M.D., with Additions. London, H. Baillière.

directions. The form of these ligaments is generally in harmony with the character of the movement to be performed by the joint, and with the nature of the osseous articular surfaces. It is a singular fact, that the ligaments which are insensible to the knife, and to ordinary stimulants, are yet strongly affected when an attempt is made to twist the joint beyond due limits. When such a motion is required, nature provides for it, either by lengthening the ligament or providing in its place a fibro-cartilage, which admits of being twisted, to a certain extent, without injury. The intervertebral substances, for example, admit of this kind of motion; so also does the triangular fibro-cartilage which connects the lower extremity of the radius to the ulna.

The active organs of motion are the muscles, forming about a half of the whole mass of the body (Pl. 5, 6, 7. Figs. 1, 1, & 2). They are infinitely varied in form and size, but agree in their powers of contraction, or shortening their fibres. On this faculty depends the whole of their functions. When a muscle contracts, it swells and shortens, and its two extremities approaching each other with a force at times irresistible, it of necessity follows that the bones to which they are attached must follow. This action of the muscles is caused by the nervous system acted on by the will or by other stimulants; but the nature of muscular contractility is wholly unknown. Like many other organs of the body, the muscles, attaining their full development about the age of thirty-six in man, and twenty-seven in woman, waste away in the aged, becoming at the same time soft, flaccid and feeble. It is in the athlete, or prize-fighter, that the muscular system attains its highest

development. By exercise, the strength, and, perhaps, even the bulk of the muscles may be increased, but never can be made to attain the power, strength, and rapidity of action we find in those on whom nature has bestowed the natural development of the athlete.

To understand the mechanism of the movements of the body and limbs, it is necessary to view the bones as levers, which they really are, and the muscles as the active powers or force. This subject is usually treated of at great length in works on animal mechanics. A few observations will suffice in this place.

A lever, in mechanics, is understood to be a solid elongated body, by means of which, assisted by a fulcrum, or point of support, a resistance may be overcome. Take the lower jaw, for example: the fulcrum, or point of support, is in the joint; the acting power is the temporal muscle; the lever is the jaw itself; and the resistance to be overcome, whatever is placed between the teeth.

In this example, the resistance to be overcome is placed beyond the point of the insertion of the force, or, in plain terms, the attachment of the temporal muscle to the coronoid process of the jaw (the lever) is placed between the fulcrum, or point of support in the joint, and the resistance—that is, the body placed between the teeth. Just in proportion as this portion of the lever which is placed beyond the insertion of the force is elongated, and the resistance removed further from it, so is the power weakened; hence the difference between the bite of the lion, whose jaws are so short, and that of the horse, whose jaws are so elongated; of the bull-dog compared with the greyhound, &c.

When the resistance is placed between the point of support, or fulcrum, and the attachment of the acting force to the lever, as when we place a hard substance we wish to crush, between the backmost molar teeth—in this case, a portion of the masseter, especially in some animals, being placed in front of the resistance, that body comes to be situated between the fulcrum and the acting force, and a lever of this kind is considered as one of great power. On the other hand, when the acting power or force is attached to the lever close to the fulcrum, and the greater part of the beam to be acted on projects, as it were, beyond this attachment, the lever is weak in the ratio of this very length of the beam.

An example of this is the attachment of the deltoid muscle to the humerus. The arm, extended or not, is raised chiefly by the deltoid; if the arm be extended, and raised to a line with the shoulder, it cannot be long maintained in this position, by reason of the extension of the lever, and, of course, in this case, of the resistance to be overcome, beyond the point of attachment of the force, and a small weight becomes soon extremely heavy when placed in the hand of the extended and raised arm. But the loss of power, which unquestionably occurs to man by the attachment of the tendons of the muscles so near the fulcrum, is amply compensated for by the great range it gives to the limb so moved, regard being had to the amount of force used (see all the Figures in Pl. 5, and the accompanying explanations). Thus, the biceps and brachialis muscles, the strong flexors of the fore-arm or the arm, and *vice versá,* when the hand is fixed, are attached close to the upper

extremities of the two bones of the fore-arm, and are thus enabled, by the expenditure of a comparatively small power, to move the fore-arm and hand through a much wider range than if these attachments had been lower down—that is, nearer to the extremity of the lever and the resistance to be overcome.

This subject is still further illustrated, and sufficiently for all useful purposes, in Fig. 3, 8, and 9, Pl. 6. Thus, animal mechanics differ in many circumstances from common mechanics, although the principles are the same. The distance from the point of support, or fulcrum, to that where the power is applied, is called the *arm of the lever,* and the force or effect is in the direct ratio of the arm of the lever; but it does not follow that such an economy of the force is always studied in animal mechanics, because a living animal is not simply a machine.

One of the simplest applications of the principle of the lever is when the arm, being half flexed, we desire to bend it completely, raising, at the same time, a heavy weight in the hand; in this case, the fulcrum, or point of support, is in the elbow joint; the power, represented by the biceps and brachialis muscles (Pl. 5, Fig. 1, arm and fore-arm, anterior surface; also Pl. 6, Fig. 3, *a*), is placed in front of the articulation; the resistance to be overcome is the whole weight of all that portion of the fore-arm and hand which is beyond the insertion of the power, added to the weight the person holds in his hand.

The number of the muscles of man has been estimated at 408. They are placed generally in layers around the skeleton, and anatomists speak of them as layers, dividing

them into the superficial and deep. So long as an artery, however deep its situation may be, is not covered by any muscle, it is said, in surgical language, to be superficial; when crossed by a muscle, or other important structure, it is spoken of as deeply situated.

It will be readily understood that the muscles intended to move sections of the limbs, are, in general, situated on the section nearer to the trunk than the one to be moved. Thus, the so-called muscles of the shoulder in reality move the arm, whilst those placed on the arm act on the fore-arm and hand. It is the same as regards the lower extremities. Muscles, also, are frequently spoken of with a reference to their uses: as flexors, extensors, abductors, &c.

During life, the muscles seem to be in constant action, antagonizing, as it were, each other, and this action takes place wholly without our consciousness. If the tendons of the extensor muscles of the hand, for example, be divided or cut across, the flexor muscles will immediately act, and close the fingers permanently, not only against our will but despite every effort to the contrary.

By a careful study of the articulations, artists learn to avoid drawing impossible attitudes; the great masters were never at fault in this matter, so that no false anatomy is ever to be detected in their drawings or statues. The Laocoon of antiquity presents the most remarkable proof of the correctness of this remark.* But the Elgin marbles in the British Museum are equally admirable.

The word *attitude* is used to express any position the

* See "Artistic Anatomy," by Fau. Baillière, London.

body may assume for a longer or shorter time. It is effected solely by muscular action. I shall first make a few remarks on the character and mechanism of the human attitudes, and secondly on that of the movements by which locomotion is accomplished.

To stand erect requires not only that the line of gravity should not fall beyond the base of sustentation, but, in addition, the employment of a vast number of muscles—of the same means, in fact, which enable the body to overcome the attraction to the earth's surface, and to move from place to place. In the erect position, or attitude, the base of sustentation is the surface by which the body touches the resisting medium, whatever that be. That surface, in the erect attitude, is the feet and space between, or the foot, or a portion of the foot, as the case may be. The larger the base of sustentation, the safer will be the attitude; hence wrestlers widen the feet, with the object of enlarging the base of sustentation. On this base of sustentation the centre of gravity must fall, in order to render the position safe, or even possible; and a correct eye can generally point out any defect in this respect in statuary or painting without any application of the plummet.

In standing on both feet, we instinctively balance the equilibrium, and without the least reflection, otherwise the position would not be safe for an instant. Thus, if a weight be put into one hand, the head and shoulders are thrown to the opposite side to maintain the equilibrium; if one arm be extended, it is still the same—a counteraction must be set up to meet the change in the equilibrium.

A load on the back or shoulders compels the person to stoop forward, for the same reason, and if carried in front, the head, shoulders, and trunk generally must be proportionally thrown backwards. All this is done to maintain the position of the centre of gravity, and to keep it within the base of support or sustentation.

The erect attitude, supported on two feet, is peculiar to man amongst mammals, and is a position which he maintains with the utmost ease. And yet, to enable him to do so, an almost incredible number of muscles are called into action. Thus, the head must be balanced and supported on the spinal column by the strong muscles placed on the back of the neck; the thorax and head maintained erect by the strong muscles of the back and loins, counterbalancing the weight and preponderance of the thoracic viscera placed in front of the spinal column. The same remarks apply to the means by which the weight of the abdominal viscera is counterbalanced. Hence the reason, no doubt, of the strength of these muscles. In old age, when no longer able to counteract the weight of the thoracic and abdominal viscera, the body bends forward, the head falls towards the chest, and a staff is required to maintain the equilibrium, or, in other words, to enlarge the base of sustentation, so as to meet the forward movement of the centre of gravity. (Compare the supplementary Figure of the skeleton viewed in profile with Fig. 2, Pl. 7; also with Pl. 6 and 5.)

As regards the mechanism of the lower extremities through which the weight of the trunk is transmitted, we have proof of the great power of the haunches in man. On

these the extensor muscles are placed, of which the most powerful are the gluteal (grand fessier, great gluteal; and moyen fessier or middle gluteal, Fig. 1, Pl. 6,) the size and strength of which, are characteristic of the human form. On the back of the legs in the same figure (Fig. 1, Pl. 6,) may be seen the gastro-cnemii muscles (muscles jumeaux) left leg, and soleus (solaire) right leg; the slender plantaris is seen crossing the soleus diagonally. These muscles are also quite characteristic of the human form, and are of great strength. They form the calf of the leg, the form of which varies so greatly in different races of men, and even in individuals. By turning to Plate 5, fig. 1, the course of the extensor muscles of the thigh and leg may readily be seen. They occupy the front of the thigh and leg; those of the thigh (rectus, vasti, and crureus muscles) are so powerful, that they not unfrequently snap the patella across, especially in those who in descending a hill happen to slip; a violent and convulsive effort is made by these muscles to prevent the knee from bending, and the patella is at the moment broken transversely.

The ankle joints are maintained fixed, in like manner, by the surrounding muscles and their tendons, on the strength of which, and not on that of the ligaments, the safety of most joints wholly depends. Thus, the series of broken levers of which the skeleton is composed, becomes fixed and immoveable at will, ready, however, to act as broken levers on the instant, if required.

In Plate 5, Fig. 1, may be seen the flexors of the arm and fingers; and in Plate 6, Fig. 1, the extensors. The

flexors of the leg (semi-membranosus, semi-tendinosus, and biceps) occupy in this Plate, the back of the thigh. The strength of the peroneal muscles, also form a remarkable feature in the mechanism of the human leg; whilst the most powerful adductors serve to approximate the thighs, and to act as antagonists of the abductors and extensors.

The movements of rotation of the lower extremity are performed at the hip-joint, being provided for by a ball and socket joint, and by numerous rotating muscles. The thigh, however, cannot be extended backwards beyond the line of the body, and the apparent extension is simply a deception caused by a flexion of the trunk forwards, beyond the perpendicular.

In walking, one foot is carried forwards and placed on the ground; prior to this, the foot resting on the ground is partially raised from it by the action of the muscles of the calf of the leg; these contracting, draw up the heel bone, and the body now placed between the ground resisting the downward pressure of the toes, and the elevation of the heel bone, moves upwards against the force of gravitation. To the foot previously, or now carried forwards and placed on the ground in advance, the centre of gravity of the body is transferred, and the same muscular movement repeated. Thus, progression is accomplished, and in any direction. The mechanism of leaping, running, swinging, &c., does not materially differ from that of walking, excepting in this, that in leaping and running, there is a moment when the whole body is raised from the soil, or resisting surface.

By a careful study of the various movements of the body

based on the exact anatomy of the articulations, the artist will avoid all false drawing, and the giving to his figures *impossible* attitudes; the surgeon, on the other hand, will greatly improve his tact in the detection of dislocations and fractures, a kind of knowledge which the public imperatively demands of him.

CONCLUDING CHAPTER.

Throughout this Work I have proceeded on the generally admitted physiological principle that all the organs of animal bodies are more or less dependent on each other. Anatomical corelations no doubt exist of a remarkable character, proceeding on which, but with much caution, the immortal Cuvier was conducted to many remarkable paleontological discoveries. That he over-rated their importance, was always well-known to his cotemporaries, and now begins to be generally admitted; but they are not the less worthy of deep consideration, and of frequent application where admissible. Man, as was to be expected, furnishes many remarkable exceptions to the theory of anatomical corelations as established by Cuvier: he stands apart, to a certain extent, from all other natural families, and between the most degraded of human races, and the highest of the apes or simiæ, the gorilha, chimpanzee and orang-outang there is a gulf, even as regards structure,

which renders wholly inappropriate the fashionable term of "anthropomorphous apes."

But, although man be thus distinct and separate from all that now lives, both structurally and physiologically, forming one great family, he is yet composed of a number of distinct races, which are usually called varieties, the extent and origin of which, have not as yet been determined: neither has the consanguinity of these varieties been demonstrated by direct observation.

The origin of these varieties is lost in the stream of history, but one thing seems certain, they are of vast antiquity. To a certain extent they have geographical relations, but these are violated in many instances, or, at least, they seem to be so. Nevertheless, it may with safety be said, that in Europe only we find the absolutely fair race of men, of which the fairest is the Scandinavian, not unfrequently called Saxon; in Asia, the Mongol; in Africa, the Negro; in America, the red man, or copper-coloured Indian. These, it is true, are not the only remarkable varieties of mankind; the Polynesian, the Bosjieman, the Papuan, are more strikingly characteristic and peculiar than any of the above; nevertheless, the great continental varieties, or races, as they may be called, present by far the greatest interest to the ethnological enquirer.

These races differ from each other in their intellectual characters, and physical structure; but it is probable, and as regards structure, it is certain, that the differences are to a great extent, unimportant. The most remarkable differences which I have observed, are to be found in the

Bosjieman race. Much stress is laid by some on the kind of food to which the races seem addicted, but I feel disposed to think, that more depends on the circumstances under which the races are placed, than from any innate or inherent discrepancy in their nature. That the circumpolar races, as the Esquimaux, use only animal food, may be exclusively due to the impossibility of their obtaining any other. On this they seem to live and thrive, nor are they more subject to disease than any other of the races of men. The Dutch, long settled in Southern Africa, live to a great extent (I speak of the nomade farmers of the interior) on animal food. They are strictly, or nearly a pastoral people, their herds and flocks forming their sole wealth. Neither the Caffre nor Bosjieman, inhabiting the same country, would use vegetable food could they at all times command an animal diet. Yet these opposite and most antagonistic races enjoy equally good health. The nomade Mongol, or Tartar, as the race used to be improperly called, lived on animal food only; to the settled agricultural Chinese, of truly Mongolian origin, all descriptions of food are equally acceptable.

The wild Indian of North America cultivated nothing, grew nothing; to him agriculture, under any form, was unknown; to the south were the ancient Mexicans and Peruvians, labourers and agriculturists, with whom a mixed food was evidently in use. Yet the whole American continent, with the exception of the Arctic regions, seems originally to have been occupied by one race.

The Negro in his native land, Central Africa, is, probably, a vegetable eating race; so is the Hindoo; but

both thrive perfectly well on animal food, and seem to give it a preference, when at liberty to do so.

Although it is possible that all the races of men might, in a long series of years, become acclimatized to any country, the history of mankind as yet does not warrant such a belief. On the contrary, the races of men thrive best in the land on which they were originally found, and aggressive races from other countries, have generally, in time, become extinct. It is possible, however, that by the constant improvement of the social condition of man, the rapidity and security of intercourse, and by the spread of knowledge, the obstacles to the extension of any particular race over the earth, may, to a great extent, be overcome. As it is, intertropical countries are the graves of Europeans; there they degenerate, die, and become extinct. But this process of degeneration, decay, and extinction is not confined to tropical countries; it extends to others in which neither the temperature, nor any other meteorological influences seem adequate to account for the occurrence. The red Indian usually perishes when an attempt is made to domesticate the race, and it is said that in North America, many parts of which enjoy a comparatively warm climate, the negro degenerates, and threatens to become extinct.

As respects the influence which one race exercises over another, the history of mankind furnishes some singular and hitherto inexplicable data. The ancient Coptic or Egyptian race seems to have withstood the Persian, Greek, and Roman conquests; but it perished in presence of the Arab or Saracen. Wherever the Scandinavian or

Saxon carries his conquests, the native races have a tendency to become extinct, and if this has not happened in respect of India, it arises simply from this, that the European constitution cannot withstand the climate. This fatal influence does not seem to have marked the Roman and Greek conquests, nor the Carthaginian. On the contrary, they seem to have amalgamated with the native races, who, in some measure, adopted their civilization.

Man is everywhere the same; actuated by the same feelings, passions, and desires. It is by no means improbable, that all races are equal to a certain amount of civilization, each after its own instincts. Thus the world has seen the Coptic, Phœnician, Persian, Saracenic, Etrurian, even the Mexican, Peruvian, and Chinese forms of civilization; these, no doubt, were preceded by others. The present forms of European civilization, using the term in its most extended sense, are modelled on these, for it does not appear that any form of civilization ever originated with the western European races.

During the historic period, man's stature has not altered; his strength, and rate of increase, the duration of his individual life, diseases and external form of body, do not seem to have altered, nor even to have been greatly modified. The pictorial remains of Egypt and Etruria, and the mummies which the ancient Egyptians embalmed with such care, attest these facts. It seems to be the same with the numerous species of animals now ornamenting the globe, as proved by the labours of the immortal Cuvier. But, there was a time when the animal world presented different features; the huge and monstrous Saurians

peopled, as it were, the waters for a time; fishes wholly distinct from the present; gigantic quadrupeds, as the mastodon, the dinotherium, the sivatherium, which we presume to have been mammals, roamed over the earth. Birds of a corresponding stature were not wanting. All was on a larger scale than now, as if the vitality of the earth was then more active. All, or nearly all, have perished; amongst their remains none pertaining to any of the races of men have as yet been found.

THE END.

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